Notes on Rubber Cultivation

BY

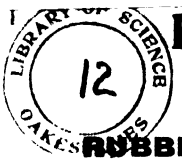
LIEUT.-COL. J. A. WYLLIE, F.R.G.S., I.A.

AND

OCTAVIANO GUILHERME FERREIRA, M.R.A.S.

WITH
SIXTEEN
FULL
PAGE
PLATES

MADRAS:
HIGGINBOTHAM & CO.
1907.



BOOKS FOR PLANTERS.

RUBBER—

Rs. A.

Notes on Rubber Cultivation, with special reference to Portuguese India. By Lt.-Col. J. A. Wyllie, F.R.G.S., and O. G. Ferreira, M.R.A.S., with 16 full-page plates. 1907 .. .. 4 8

CONTENTS :—*Introduction — Hevea Brasiliensis — Castilloa Elastica—Manihot Glaziovii—Ficus Elastica—Hancornia Speciosa—Minor Rubber Plants—Concessions of Land—Selected Estimates of Return to Capital—Scheme for a Mixed Plantation—Ceylon Exhibition, 1906 : its Lessons.*

EACH OF THE CHAPTERS *on species is divided into the following sections :—Description—Natural conditions, habits, etc.—Locality—Reproduction—Laying-out the Plantation—Harvesting—Estimates of outlay.*

THE PLATES *are reproduced from photos taken by practical rubber planters and are exceptionally instructive.*

Rubber in the East, being the Official Account of the Ceylon Rubber Exhibition held in the Royal Botanic Gardens, Peradeniya, Sept. 1906. Edited by J. C. Willis, M. Kelway Bamber and E. B. Denham. With Planting maps of Ceylon, Perak, Selangor, etc., and numerous illustrations, 1906 .. .. 3 8

Lectures and Discussions on Rubber cultivation and preparation, a descriptive account of the Ceylon Rubber Exhibition, Sept. 1906, with full list of Exhibits and Awards, notes on same and full reports of all the Lectures, etc., illustrated, 1906 .. .. 3 0

Hevea Brasiliensis or Pará Rubber: its botany, chemistry and diseases, by Herbert Wright A.R.C.S., F.L.S., *Govt. Experiment Station, Ceylon.* Second edition, with plates and diagrams, 1906 .. .. .. 5 8

Cultivation and Preparation of Pará Rubber, by W. H. Johnson. 1905 .. .. 6 9

COFFEE—

Brazil as a Coffee-growing Country: its Capabilities, the Modes of Cultivation and Prospects of Extension, described in a Series of Letters from the late Mr. G. A. Cruwell and Mr. A. Scott Blacklaw 0 8

Cameron, John, F.L.S.—The Prevention of Leaf-disease in Coffee. Report of a visit to Coorg .. .. 1889 .. 0 8

Coffee Planter's Manual, for both the Arabian and Liberian Species; to which is added a variety of information useful to Planters, including a Summary of the latest Practical Opinions on the Different Operations required on Coffee Plantations, etc. Compiled from the Original Manual, by the late A. Brown of Kandy, and a variety of other Authorities, by J. Ferguson, Editor, "Ceylon Observer" and "Tropical Agriculturist." 3 8

The Planter's Manual. An abridgment of "The Coffee Planter of St. Domingo," by Laborie, also notes on the propagation and cultivation of the Medicinal Cinchonas or Peruvian bark trees by W. G. McIvor, 1877 .. .. 2 0

Coffee Tree and its Enemies, being observations on the Natural History of the Enemies of the Coffee Tree in Ceylon, by the late J. Nietner. Second Edition. Revised 1 8

OTHAM & CO., Madras and Bangalore.

BOOKS FOR PLANTERS.

TEA—

	Rs.	A.
Hamlin, E. W. (Rustic.) An Essay on Tea Pruning, 2nd Edition ..	1	8
The Neilgherry Tea Planter, by J. Macpherson, Gold Medallist, 1870.	1	0

CINCHONA—

Cinchona Culture in British India, being a sketch of its origin, with practical hints on the chief points connected with the industry, by Surgeon-Major G. Bidie, with 4 plates, 1881. Paper covers .. for .. 0 14

*** *No. 13 of the Museum Popular Lectures.*

Cinchona Cultivation. Prize Essay written for the Dikoya Planters' Association, by Thomas North Christie. Containing experience by a Practical Planter 1 4

Medicinal Cinchonas. Notes on the propagation and cultivation of the Medicinal Cinchonas or Peruvian bark trees, with a letter on the cultivation of Cinchona on the Nilgiris, by the late W. G. McIvor, F.R.G.S., etc.

The Cinchona Planter's Manual, by T. C. Owen 4 0

GARDENING—

Firminger's Manual of Gardening, 5th Edition, revised by J. Cameron of the Lal Bagh, Bangalore, fully illustrated. 1904 .. 4 0

CONTENTS.—*A notice of the Author—Introduction—The Operations of Gardening—The Vegetable Garden—The Fruit Garden—The Flower Garden (300 pages). Appendix—Index to English names of Plants, etc., Index of Latin names and Index to Native names.*

Hints to the Amateur Gardeners of Southern India, by A. T. Jaffrey, 2nd Edition, with chapters on Crotons, Foliage plants, Palms and Cycads 1 8

Practical hints on Flower Gardening in Madras, by F. H. L. .. 1 0

Requisites for a Flower Garden—Shape of Flower beds—Soils and Manures—Plants suitable for Madras—On Potting Creepers and Climbers—Miscellaneous—Gardening Calendar.

Flowers and Gardens in India.—A Manual for Beginners. By Mrs. R. Temple-Wright, Fifth Edition. Post 8vo, boards .. 2 8

Woodrow's Gardening in India. With an Introduction, a Chapter on Plant Breeding, 43 Supplementary pages and 4 new Illustrations. 690 pages, 8vo and, full or double-page illustrations 4 0

MISCELLANEOUS—

Brown's Trees of Madras. A Handbook of the trees, shrubs and herbaceous plants growing in the Madras Agri-horticultural Society's Gardens, and neighbourhood of Madras, arranged according to the natural system, by R. N. Brown, with supplement by J. J. Wood, Professor of Botany 3 0

The Cultivation of Silkworms. A Guide to their rational treatment, with notes on every species grown in Ceylon, with illustrations, plans and estimates by Percy N. Braine .. .. .. 1904 .. 3 0

Indian Sericulture, A Bird's eye view of, by M. G. Mukerji. Illus. 1907 .. .. 0 8

HIGGINBOTHAM & CO., Madras and Bangalore.

NOTES

ON

RUBBER-CULTIVATION;

With Special Reference to Portuguese India.

BY

J. A. WYLLIE, F.R.G.S., Lieut.-Col., I.A.,

Late in Charge, Cantonment Rubber Plantations, Kambé, Rangoon;

AND

OCTAVIANO GUILHERME FERREIRA, M.R.A.S.,

Director da Bibliotheca Nacional de Nova Goa,
Vice-Consul de Francia em Goa, etc., etc.

WITH 16 FULL PAGE PLATES.

Madras:
HIGGINBOTHAM & CO.

1907.

PRINTED BY

HIGGINBOTHAM & CO., MADRAS AND BANGALORE.

PREFACE

To the English Edition.

These Notes were originally compiled for publication in Portuguese only, with special reference to the Decree of the Ministry of Marine and Ultramar, dated Lisbon, 20th March, 1906, by which certain arrangements were made for the grant of lands in the Novas Conquistas of Portuguese India for cotton-growing—arrangements which however are sufficiently ample in their scope to cover the case of India-rubber as well. But as the bulk of the contents of the Notes may, with but little modification, be applied to the case of the surrounding British districts, where at this moment practical attention is being given to the question of rubber-cultivation, it occurs to the writers that an English Edition, issued simultaneously with the Portuguese version, may serve a useful purpose. To this end, then, the Notes are offered, with the (possibly superfluous) remark that they do not pretend to be much more than a resumé of results recorded by others, with here and there an observation based on personal experience. The sources to which the authors are indebted are acknowledged in the text throughout. Special thanks are due to Mr. C. G. Northway, of the Deviturei Estate, Elpitiya, Ceylon, and to the Colombo Apothecaries' Co., Limited, for their kind permission to use photographs relating to the growth and development of the Pará-rubber plant.

Nova Goa,
November 1906.

J. A W.
O. G. F.

NOTES ON RUBBER-CULTIVATION.

CONTENTS.

CHAPTER III.

CASTILLOA ELASTICA.

CHAPTER IV.

MANIHOT GLAZIOVII.

CHAPTER V.

FICUS ELASTICA.

CHAPTER VI.

HANCORNIA SPECIOSA.

CHAPTER VII.

MINOR RUBBER PLANTS.

CHAPTER VIII.

CONCESSIONS OF LAND FOR RUBBER-PLANTING.

CHAPTER IX.

SELECTED ESTIMATES OF RETURN TO CAPITAL.

CHAPTER X.

SCHEME FOR A MIXED PLANTATION.

CHAPTER XI.

CEYLON RUBBER EXHIBITION, 1906: ITS LESSONS.

LIST OF ILLUSTRATIONS.

Lista das Gravuras.

PLATE I (*a*).—Treatment of the first coagulum of latex; Machine for washing it.

(*b*).—Process of production of crêpe rubber from coagulum washed as above.

NOTES

ON RUBBER-CULTIVATION;

With special reference to Portuguese India.

CHAPTER I.

INTRODUCTION.

INDIA-RUBBER and gutta-percha, as commercial products, are formed by coagulating, either spontaneously or by means of heat, smoke, or mechanical agency, the latex or milky juice yielded by certain plants belonging to the natural orders Apocynaceæ, Euphorbiaceæ, Urticaceæ, and Asclepiadeæ. The term caoutchouc is used (in English at least) in a restricted sense, to denote the pure hydrocarbon as distinct from the raw product, after separation of the resins, proteids, and other alien elements contained in the crude rubber of commerce. The word is derived from *caucho*, the name given by the Indians of the Amazon valley to the tree now known to botanists as *Castilloa elastica*—the first rubber-tree to be discovered by European explorers in the New World. As regards their essential components, india-rubber and gutta-percha are chemically identical, but their physical properties are distinct, the latter being non-elastic but becoming plastic under the influence of moderate heat, the former remaining elastic and not amenable to moulding at the same temperature. Thus a slab of gutta-percha left for a short time in warm water can be made to assume any desired form, and will retain that form on cooling down while a slab of india-rubber similarly treated will retain its resiliency, resuming its first form as soon as released from any strain of tension or compression to which it may have been subjected.

These statements must be read as theoretical and restricted in their application to a typical rubber or gutta of the highest purity. The ideal rubber, and the ideal gutta, may be regarded as standing at either end of a scale, intermediate between the two extremes of which lie a number of more or less useful products containing caoutchouc. These range, in the descending scale, from a commercially high-grade rubber, through second-grade and inferior gum-elastics, to a group of non-descript substances partaking of the nature of both a rubber and a gutta; and, in the ascending scale from this point, through the pseudo and second-grade guttas to a commercially high-grade article approximate to the standard gutta of the theory.

The following list of rubbers and guttas is by no means exhaustive, the known species being more than ten times as many, but for practical purposes it may be regarded as including all the cultivable kinds, with several that have attracted attention but are unlikely to prove remunerative to the planter. It is arranged in the form of a descending and ascending scale, to illustrate the preceding point.

Standard Rubber—	(*a*)	**Standard Gutta—**
Hevea brasiliensis.		Dichopsis gutta.
2nd-Grade Rubbers—	(*b*)	**2nd-Grade Guttas—**
Parameria glandulifera.		Dichopsis oblongifolia.
Castilloa elastica.		Payena leerii.
Chavannesia esculenta.		Willughbeia edulis.
3rd-Grade Rubbers—	(*c*)	**3rd-Grade Guttas—**
Manihot glaziovii.		Dichopsis polyantha.
Ficus elastica.		,, pustulata.
Hancornia speciosa.		,, elliptica.
Inferior Rubbers—	(*d*)	**Pseudo-Guttas—**
Landolphia kirkii.		Mimusops balata.
Funtumia elastica.		Calotropis gigantea.

(*e*)

Non-descript Products—

Ficus laccifera. Alstonia scholaris.
Euphorbia neriifolia.
Artocarpus integrifolia.

The Bombay Chamber of Commerce recently (October 1905) addressed the Government of Bombay on the subject of rubber and gutta cultivation, suggesting among other matters the experimental planting of the *Dichopsis gutta* or true gutta-percha tree, which they contended might be grown wherever the indigenous Indian species (*Dichopsis elliptica*) was to be found. The latter is no doubt recognised as a tree of the Bombay forests. But the question of acclimatising the true or indeed any gutta-tree of commercial value though a most interesting one from several points of view, is beset with difficulties—indeed expert opinion is against its practicability at all. The late Dr. Obach, probably the soundest modern authority on this subject, in the course of three lectures delivered before the (London) Society of Arts in 1897, exhibited some photographs of successful plantations of *Dichopsis gutta* at Buitenzorg on the northern coast of Java, and at Tjipetir, 1,300 ft. above sea-level, towards its southern coast. The lecturer had previously invited the attention of his audience to a specially-prepared map of the region from which alone all genuine gutta had up to then been derived. He went on to remark:—

"You will observe that the boundary (of the region described) extends six degrees on either side of the equator, and from 99 degrees to 119 degrees eastern longitude; it therefore embraces 12 degrees of latitude and 20 degrees of longitude, corresponding to an area of 1,140,000 square miles, but of this only about 40 per cent. is occupied by land, and of that again only a very small portion is locally suitable for the growth of the gutta-percha tree.

"Nowhere else on the globe, outside this area of the Malay Archipelago, have any genuine gutta-percha trees been found, and this is the more remarkable as the *Sapotaceæ* to which they belong are distributed all over the tropics, and are also of great antiquity, having representatives even among the fosil plants. It might, perhaps, be asked whether gutta trees have not been found in the islands adjacent to those confined by the boundary-line on the map; for instance in the large group to the north of Borneo, the Phillippines, or the islands of Celebes and Java, to mention only the more important ones. The answer is that hitherto no genuine gutta-percha trees have been discovered there. *Getah* trees, in the Malayan sense of the word, exist no doubt, but none of the right description."

The lecturer then went on to cite geological and zoological facts proving that Celebes and the Lesser Sunda Islands were ancient continental islands, belonging to the Austro-Malayan rather than to the Indo-Malayan region. He pointed out that the fauna and flora of Bali and of Lombok, for instance, islands on either side of the line of division, though only 15 miles apart, differed more widely than those of Great Britain and Japan, with two continents intervening. And he further showed that though Java and the Phillippines admittedly belonged to the Indo-Malayan continental area, the Sapotads of that area were not, at the geological period of separation from the mainland, sufficiently differentiated to produce the *species* which furnish a gutta-yielding latex. From these data he proceded to trace out on the map the limits of the true gutta-producing region of the present day.

The southern boundary of the region in question passes east and west through the Straits of Sunda so as to exclude the whole of Java, and consequently runs a few miles to the north of Buitenzorg, and about 180 miles to the north of Tjipetir, the two places where the tree has been successfully cultivated. The lecturer mentioned that some specimens of a gutta-percha (probably, he thinks the *D. polyantha*) had been sent to the Ceylon Botanic Gardens in 1882, but from the absence of all reference to them in the Botanic Reports of 1896 he presumed that had disappeared from that island. However, the Bulletin of the Imperial Institute (quoted in the Ceylon Tropical Agriculturist, December 1903, p. 399) mentions a gutta which it styles *Palaquium petiolata* (Engler) as abundant in South-West Ceylon, and gives a very full report of its product. This may have been the same plant. *Palaquium* and *Dichopsis* are synonyms. But the presence, whether indigenous or introduced, of an other Sapotad proves nothing in favour of the possibility of acclimatizing the true gutta-tree. The *D. polyantha* has naturally a wide distribution, being found as far north as 20 N. in the Arakan Hill Tracts (Kurz, Forest Flora

of British Burma, describes it under *Isonandra polyantha*, another synonym). The present writer has seen samples of the so-called gutta from this tree, obtained in the Shan States in 1896, which burned with the characteristic odour of caoutchouc, but in the cold state could be cut like wax. The produce of the Ceylon tree (*P. petiolata*) appears to have been of equally little value. Its analysis, as given by the Imperial Institute, was thus:—

Samples.	(*a*)	(*b*)	(*c*)
Contained Resin	68·9 per cent.	72·2 per cent.	68·9 per cent.
Gutta (?)	27·2 ,,	26·3 ,,	25·5 ,,
Dirt	3·9 ,,	1·5 ,,	5·6 ,,
	100·0	100·0	100·0

Samples (*a*) and (*b*) proved friable, easily reducible to powder, and sample (*c*) softened in the hand, without artificial heating, to such an extent that it could be bent without breaking. None had any strength or insulating value, and the brokers priced the lot at 1½*d.* per lb.

Taking it all round, the prospects of plantation gutta anywhere outside Malaysia do not appear encouraging. If any planter is public-spirited enough to go to the expense and trouble of making an interesting but somewhat uncertain experiment, his attention might be directed to two plants on the list—the *Willughbeia edulis*, found along the Tenasserim Coast of Lower Burma, and the *Mimusops balata*, a giant tree of Guiana and Venezuela. The former has been very favourably reported upon of late years, and the produce of the latter is well known in the British market.

But it is not intended, in these notes, to discuss the question of gutta-cultivation any further. The list of plants yielding caoutchouc, discarding the guttas, is still a long one. Twelve genera, including some sixty species, were recorded as known to Botanists in the eighties, and it is probable that a revision of the list, including the root-rubbers, would bring its total to a figure close upon the

hundred. But many of these plants contain rubber in such very small quantities as to be of little more than botanic interest, while others (notably most of the rubber-vines) do not lend themselves freely to tapping, and must be cut down to yield their full value. A third class, of which I should be inclined to take *Manihot glaziovii* as the type, do not when acclimatized yield rubber with the same freedom as in their native land. The elimination of these unprofitable species reduces the list to quite manageable dimensions. A selection has therefore been made of such plants as may repay cultivation.

But before proceeding to describe each plant singly, it may be of interest to form some idea of the extent to which each contributes to the world's present supply of crude rubber. This can only be approximately determined, but we are not entirely without data on the point. The ports corresponding to the regions where crude rubber alone is dealt with, the species mainly, if not exclusively yielding that rubber, and the annual shipments, are known. As regards the world's total annual consumption of rubber, the figures of experts differ notably. Dr. D. Morris for example (Journ. Soc. Arts, xlvi, 745—746) estimating it as 60,000 tons, and Dr. Warburg of Berlin (Plantes à Caoutchouc, Paris, 1902) at only 42,000 tons. To arrive at a reasonably accurate idea of the annual consumption, a careful calculation was made about six years ago by the *India-Rubber World* (New York, April 1900). By deducting re-exports of crude rubber during the year from imports for the same period into the States and the various European countries which may be reckoned as consumers of the commodity, the following results were arrived at for the three immediately preceding years:—

1897	...	42,898 tons.
1898	...	47,926 „
1899	...	51,032 „

The figures for the three following years are not avail-

able, but the Tropical Agriculturist of July 1906 records a further calculation on much the same lines, *viz.*:—

1903	...	50,884 tons.
1904	...	55,384 „
1905	...	61,397 „

The intervening years in all probability showed a fluctuation inasmuch as the figure for 1903 is lower than that for 1899, but taking the record from first to last an annual increase in the demand, amounting to 4·8 per cent. from year to year on the average, is established.

Retaining the classification of quality of the various species of rubbers given above, and applying to the last figure of world's consumption (for 1905) the statistics of export trade furnished month by month by Messrs. Hecht Frères & Cie. of Paris, the eminent rubber-brokers, the calculation will stand thus:—

		Tons.	Per cent.
Standard Rubber.			
Hevea brasiliensis (Amazon Valley, Bolivia, etc).	34,710		
Do. Plantation (Straits, Ceylon, etc.)	140	34,850	56·8
Second-Grade Rubbers.			
Castilloa elastica (including Amazon *caucho*)	3,160		
Parameria glandulifera (from Tonkin)	350	3,510	5·7
Third-Grade Rubbers.			
Manihot glaziovii (from Ceará)	600		
Ficus elastica (Assam, Burma, Straits)	1,800		
Hancornia speciosa (Bahia, Pernambuco, etc.)	1,760	4,160	6·8
		42,520	
Inferior Grades.			
Misc. African Rubbers (Funtumia, Carpodinus, etc.)		18,877	30·7
Total of Year's Consumption		61,397	Tons.

The charts that follow, also compiled from Messrs. Hecht's returns, show the movement of crude rubber prices for 16 years, and the progress made by Plantation

vation of *Hevea* and of rubber-vines in general, reckoning on this very exhaustion of the natural sources of supply

"M. Cibot thinks thus, even as regards the *Hevea*, which is the most resistant and at the same time the most important of the known sources of rubber. But even were the natural rubber-groves to last longer than is expected, does it follow that the plantation of rubber is doomed to ruin for want of a market? We do not think so, for the simple reason that the last word has not been said as to the industrial applications of india-rubber.

"It is probable that up to a certain limit, as yet very far distant, the greater the output of rubber the greater the consumption of it, especially if the price of the raw material goes down. Not to speak of new uses, what might the increased demand not be when the manufacturers, finding it to their advantage to do so, started using good unadulterated rubber in the making of various articles having at present but little rubber in them beyond the name, and doing no particular credit to it either!

"On the other hand it is quite on the cards that the cultivated *Hevea* rubber of the east and of Java may yield a better account of itself than that of the forests of the Amazon basin. This has already been seen in the case of the cinchonas, formerly drawn from the forests of South America. Now-a-days Java more or less supplies the whole world with the drug."

M. Cibot does not by any means stand alone as regards these views. It is however but fair to the reader to state the case for the other side. For the benefit, then of those who may desire to examine the question for themselves, the following collection of opposite views is offered:—

Against M. Cibot's View.

Consul Churchill, Para. to H. B. M. Foreign Office, 1st October, 1898.

The most competent authorities maintain that the supply is inexhaustible, because the *Hevea* is constantly being reproduced by nature. Certainly some areas become exhausted when overworked, but when left alone for some time they recover. The district of Cameta is now exhausted, because for about

In Agreement with M. Cibot.

Consul Orton Kerbey (U. S. A.), Para. to Editor, India-Rubber World, 10th August, 1899.

I have travelled much in the States where the best rubber abounds and am convinced that the extinction of the rubber-trees on the Lower Amazon is only a question of time. Already, official statistics of the State of Pará confirm my view. To determine the location and extent of the reserve forests of

forty years thousands of men have tapped its trees. But there are many districts that have not been tapped. The area that is known to produce Pará rubber amounts to at least 1,000,000 square miles. The most prolific part is on the river Acre. Here 100 trees yield as much as one ton of rubber per annum.

India-Rubber Trades Journal.

(Leader, issue of 12th June, 1897.)

The cry that the natural supply of rubber will soon be exhausted is naturally one that will take with the uninitated. Let us not be misunderstood in this matter. There are many parts of the world where rubber at present grows that are practically unknown and have never been worked in any way. So long as there is any demand for raw rubber at a price that will pay those at present engaged in the trade, so long will there be men who can collect and supply it profitably, but when it is produced more plentifully than is required the price will fall, so that though there may be a bigger consumption the bigger supply will cause a fall in spite of it. It pays to collect rubber, but companies over-

the Amazon basin, I have explored that river from end to end, suffering the wreck of my canoe in regions never before visited by a white man, crossing the Andes five times, and travelling consecutively from Mallendo on the Pacific to Pará. The information I have gained is of interest; how to make it of practical value is another story. Political conditions in part of the territory at least (Acre) are too unstable.

New York India-Rubber World.

(Leader, issue of 1st September, 1899).

The future extent of the rubber supply and the standard of prices of the crude material are still an open question. A greater use of rubber is evident from the expansion of long-established factories and the establishment of many new ones. All this lends new interest to the question whether we shall have an increased production of rubber or even a maintenance of the present rate of supply.

Already the official statistics of Pará report a falling-off in the lower districts, the increased output being gained from up the river. While rubber manufacturers probably care little whether their supplies come through Pará or Manãos a change might have a practical bearing . . the exhaustion begun

capitalised by reason of large amounts paid for purchase-money will never be likely to compete with traders who have none of these impediments to contend with.

India-Rubber in Honduras.

(The Sun, New York, June 1899.)

Dr. Polycarpo Bonilla, former President of Honduras, interviewed for the "Sun" stated :—

"There is more money to be made in my country in rubber than in tobacco. Honduras is literally a forest of rubber-trees, but there has been no attempt to develop the industry."

in the Pará district may be repeated all the way back to the Andes. The report just made to Government by the U. S. Gunboat Wilmington is of interest. It appears to Commander Todd that the rubber-trees have been pretty thoroughly "worked" along the margins of the rivers, and even should trees be found abundant in the interior, he doubts if the collectors could reach them . . , scattered through dense forests of other growth and away from navigable rivers, where means of transport does not exist. This transportation problem affects not only the movement of rubber; the shipment of the goods used in barter for the rubber, and also of the food for the gatherers, practically none being produced in the rubber district have to be considered. Another feature is the scarcity of native labour in the Amazon rubber tracts.

In addition to any doubt that may be raised by our imperfect acquaintance with the extent of the unworked natural sources of supply, an element of uncertainty to be seriously reckoned with is the possibility, in the near future, of a cheap synthetic rubber coming on the market to the detriment of the natural article. He would be a bold man who should venture to pronounce the manufacture of a synthetic caoutchouc an impossibility, but as to its immediate probability on a commercially remunerative scale, there are data by means of which the planter may rest re-assured. Dr. Tilden's experiments with isoprene more than twenty years ago are notable as "forming a stepping-stone," to quote the late Dr. Obach (Lectures on gutta-percha, 1897), "in the synthetic production of

caoutchouc and gutta-percha from the lower terpenes." Isoprene has been known since 1835 as one of the products of the destructive distillation of india-rubber (and, since 1860, of gutta-percha as well). But it was not until 1884 that an identical hydrocarbon liquid was obtained by the action of moderate heat upon oil of turpentine (and certain other vegetable oils). Dr. Tilden found first, that isoprene could be reconverted into caoutchouc by contact with concentrated hydrochloric acid, and, second, that the identical liquid obtained from oil of turpentine, left for some months in a stoppered bottle, became partially transformed into a rubber answering to all the ordinary tests of caoutchouc, including vulcanization. But the change from isoprene to india-rubber proved extremely slow, taking several years to complete, and after many attempts to hasten the process the only result attained by Dr. Tilden was the production of colophene, a thick sticky oil, quite useless as a rubber. His explanatory theory of the spontaneous change was that acetic or formic acid had been produced by the oxidizing action of the air, and that this acid had effected the transformation. But, however interesting from a scientific point of view, the still more interesting fact (from the standpoint of the planter) remains that nearly a quarter of a century has elapsed without the discovery having been turned to commercial account, due probably to the extreme difficulty of handling so volatile a product as isoprene (its boiling point is stated to be 36° Fahr.!).

The Scientific American (June 1898), in commenting on the importance of the discovery, enumerates a variety of rubber-substitutes, so-called most of which deserve no better name than adulterants, and though largely used in the trade, possess none of the characteristics of true rubber. Linseed oil boiled to a glue, and fused with a rosin while hot, gives a product outwardly resembling rubber, with a certain elasticity in it, but incapable of vulcanization. Another article, known as French gutta-

percha, is composed of equal parts of wood-tar oil and coal-tar oil with two parts of hemp oil, maintained at a temperature of from 30 to 50 over boiling point for some hours, and then mixed with half its weight of boiled linseed oil and a small addition of ozokerit and spermaceti. It is then re-heated and mixed with one-fifteenth part of sulphur. But as it has to get a quantity of india-rubber added to it to give it the required elasticity, it can in no sense be called a substitute.

A third so-called substitute, somewhat similarly composed, was the subject of patents taken out in 1898. It received the title of "Fenton's Artificial India-rubber." Regarding it, the eminent chemist who has done so much for rubber and questions relating to it, Dr. Carl Otto Weber, writes to the *India-Rubber Trades Journal* to say that the patents in question are utterly invalid. "Common to all these patents," he explains, "is the use of some oxidizable oil as a starting point. If only at last these would-be inventors could be got to realise that the production or synthesis of something approaching rubber, or even a real rubber-substitute free from fatty oils (glycerides), is perfectly hopeless, some useful result might follow by these people diverting their attention to other substances. The great value of india-rubber lies in its being a hydro-carbon, *i.e.*, a body highly indifferent to chemical re-agents and physical influences, whereas all fatty oils are within the former, nor do they at all possess the last-named properties."

The latest pronouncement in the scientific world on this matter is specially re-assuring. In his opening address to the British Association, delivered at York on the 3rd of August of the present year (1906), Professor Ray Lankester remarked:—

"The production of caoutchouc by chemical means has virtually been accomplished in its formation from isoprene. The exact nature of this change has still to be determined. When this has been done *it will only remain to cheapen* " (the italics are

ours) " *the cost of production* to make the manufacture of synthetic rubber a purely practical problem. I should be the last to discourage the great extension of rubber planting which is now taking place. It has also to be remembered that the actual cost of production of raw rubber, which is at present about one shilling per pound, will probably be reduced, and the market price of rubber may eventually be so considerably lowered that, as with quinine, the synthetic production could not be profitably carried on."

The reader may draw his own conclusions. Those suggested to him for approval are:

first, that though synthetic rubber has, scientifically speaking, been an accomplished fact for more than forty years, no practical inventor has as yet translated the chemical discovery into pounds, shillings and pence;

next, that though the world's demand for crude rubber has during the past sixteen years been increasing at the rate of nearly 5 % per annum, the output of plantation rubber is to that of wild rubber as 1 : 250;

further, that so long as the planter can keep his cost of production down to a shilling per lb., he need not be discouraged by the competition of either the chemist or the *Seringueiro;*

and, finally, that there now is, and will be for many years to come, an ample field for the *bonâ-fide* rubber-planter wherever he can make the plant to grow.

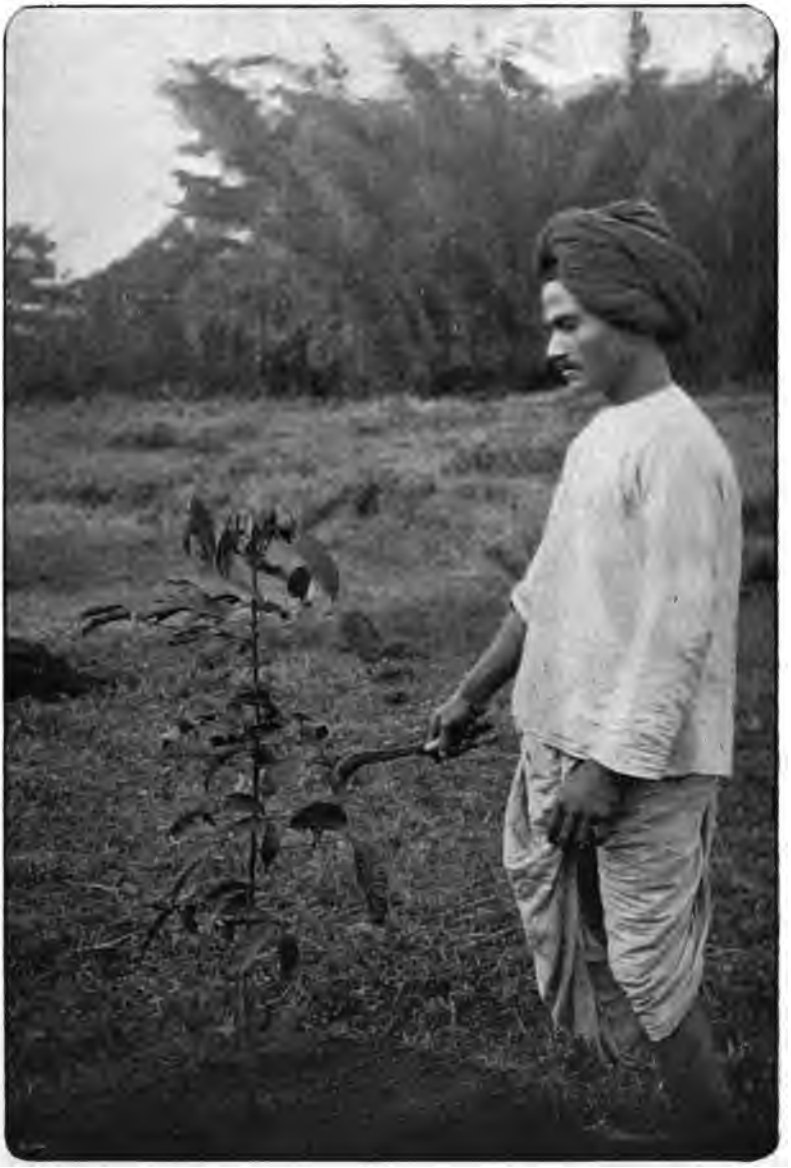


PLATE II.—Young Hevea Brasiliensis (18 months old) at Belgaum, 2,100 feet above sea-level.

CHAPTER II.

HEVEA BRASILIENSIS.

1.—DESCRIPTION OF THE PLANT.

THIS is a tree belonging to the natural order Euphorbiaceæ. Botanists describe a dozen or more species of *Hevea*, and several varieties of *H. brasiliensis* itself. Rubber gatherers, too, in the regions where *Hevea* is indigenous, discriminate between the good and the bad kinds of *Hevea*, that is to say, between those worth tapping and those not. Our information is not yet so complete as to enable us to say definitely whether these technical distinctions coincide or not with botanical diagnosis. Bolivia rubber, for example, came prominently to the front about four or five years ago, commanding higher prices in the market than Fine Pará itself. It is known to be the product of a *Hevea*, and M. Paul Cibot ("Journ. d'Ag. Tropicale," No. 18, December 1902) states that in Bolivia the gatherers recognise three sorts of *syringa* (the name there given to the *Hevea*), distinguished from one another by the colour of their bark, namely a white, a yellow, and a mulberry-coloured, the last-named being the richest in latex and the most sought after in consequence.

But to the cultivator at the present stage in the history of rubber-growing, these distinctions, valuable as they would certainly be were the enterprise in its infancy, may be regarded as of little more than academic importance, seeing that the *Hevea* already introduced to the east and grown remuneratively on a fairly large scale is the only variety the planter in Western India (for whom these notes are intended) is likely to have to deal with. Bolivia is too inaccessible and the difficulties in the way of obtaining living specimens of plants or seeds for reproduction too great to warrant the delay and expense of seeking out what may or may not prove to be more valuable varieties.

The tree that has become acclimatised in the Straits, in Ceylon, and in Southern India, commonly known as the Pará rubber-tree, has a straight cylindrical trunk, with a thin grey or yellowish-grey bark, and grows to a height of anything between 60 and 100 feet. It is estimated to grow 6 to 10 feet per annum in height, and 4 to 5 inches per annum in girth during the first three or four years. Its taproot is of fair size, and its lateral rootlets form a thick web. The rate of growth of the latter for planting purposes may be reckoned at one foot radius per annum for at least the first ten years of its life. Its leaves are composed of three lance-shaped pointed leaflets, pendent on a petiole from 6 to 9 or 10 inches in length. The leaflets themselves vary within much the same measurements, and those on mature trees are not always the largest; frequently the reverse. They are smooth, tan-coloured at their first appearance, assuming a dull-green as they unfold. In the first two or three years of its growth the tree is evergreen, but it sheds its leaves annually at the close of the rains after the third or fourth year. It is interesting to note that in the Amazon and Orinoco valleys, where the rainy and dry seasons are reversed, the fall of the leaves as well as the flowering and fruiting seasons of the tree are likewise reversed.

The crown of the tree may spread to 30 feet diameter by the tenth year, and to 40 feet by the twentieth, but this of course depends on the proximity of other trees in the forest. The flowers appear in axillary panicles of small cymes, male and female together. They are insignificant-looking, white, both formed in a bell-shaped calyx, five-toothed, the male with five stamens joined in a little cylindrical column rather shorter than the calyx, and oval anthers, attached a little below the column. The female flower, which is solitary on the top of the terminal cyme, has three stigmata, flat, with two lobes supported direct by a globular trilocular ovary, not engaged in the calyx. The fruit is a woody capsule, at first yellow, turn-

ing brown or greyish-brown outside, about the size of a garden tomato, and is composed of three lobes opening each by two valves and containing three shiny brown or coffee-coloured seeds, the tunic thin and mottled with black, not unlike a chestnut. The nut is ovoid, about ¾ inches long, and yields a large quantity of violet coloured edible oil. The germ contains an active purgative principle, not found in the rest of the seed, and this of course has to be carefully removed before proceeding to extract oil from the nut. When the capsule is left to ripen on the tree it explodes noisily and scatters the seeds to a distance. The wood of the tree is soft and valueless; fallen branches decay very rapidly on the ground.

To the planter, the most important feature of the tree is its laticiferous system. As in most if not all of the latex-yielding plants of the tropics, the tubes containing the milk from which the rubber is extracted run from the roots up the trunk and along the branches into the leaves. In the guttas they are to be found in the pith as well, and this to a certain extent is also the case with the *Castilloa* rubber-tree, but in almost all the rubbers they lie only between the bark and the cambium, close to but not penetrating the latter. They are not necessarily continuous ducts, like the blood-vessels of animals, but rather series of sacs or cells arranged vertically, the transverse walls of which tend to break down and unite the neighbouring but isolated vessels. In some species (*e.g.*, the *Manihot glaziovii*) this tendency is less than in others, and such a plant does not consequently lend itself freely to tapping. In the *Heveas*, however, the reverse is the case. But while latex is to be found throughout the tree from root to crown, that at either extremity is poorer in rubber than that of the trunk, and in the best interests of the planter as well as of the consumer of rubber all but the trunk rubber should be treated as non-existent.

2.—NATURAL CONDITIONS, HABITS, Etc.

The *Hevea* is found in mixed forests throughout the Amazon valley, on the Orinoco, and in Bolivia and Peru at a considerable elevation. It has thus a fairly wide range, though essentially a tropical if not an equatorial plant. In the Amazon delta, and up that river to Manãos, a distance of a thousand miles, the climate is very equable, ranging from 74 to 87 Fahr., though temperatures of 94 or 95 have been recorded. The rainfall varies from 80 to 120 inches, falling chiefly from January to June, the air however remaining laden with moisture for the rest of the year. The greater part of the area drained by the Amazon and its tributaries, and by the Cassiquiare, connecting the Amazon with the Orinoco, consists of dense forests growing on almost level plains, over which the rivers rise submerging for three or four months of the year the trunks of all the trees for hundreds of miles. These territories are uninhabited as might be expected from their nature, except for the annual immigration of the rubber-gatherers. The best rubber-trees are not to be found on the banks of the rivers, probably because of the accessibility of the tree standing there in times past and their consequent destruction by overtapping, or by water logging pure and simple. The highlands of Bolivia have of recent years furnished a remarkably fine quality of rubber from trees of the *Hevea* species, most of it finding its way *viâ* Iquitos and Manãos into the European or North American market, but a certain portion is shipped from Peruvian ports as well. It has been stated, and apparently with reason, that the tree does not stand extremes of temperature, but from the regions in which it is known to exist, it may be taken that a temperature falling not much below 60° Fahr. does it no harm. Another statement frequently made regarding it, namely that it will not grow on open ground, and generally dies if the ground around it is cleared, is by no means to be accepted without qualification. The former if true at all is only true of the young plant, and the latter depends on the nature of the growth that is cleared.

PLATE III (*a*).—Pará rubber 15 months old, planted in swampy land (Deviturei Estate, Ceylon).

(*b*).—Pará rubber in marshy ground similar to that of its native land.

PLATE IV.—Pará rubber, with taproot in 5 feet of subsoil water.

Grass, sensitive plant, and similar herbaceous covering may be left with positive advantage, but bushes and scrub likely to interfere with the feeding rootlets of the tree should be removed at the earliest possible opportunity, if not done before the planting-out of the seedlings. Scrubby plants in the Amazon forests would in all probability have no chance of interfering with the larger trees, being killed by total submersion in the high floods.

3.—LOCALITY FOR PLANTING.

The planter's main object will of course be to discover a region as similar as possible in character, having regard to elevation, soil and climate to that of the original home of the plant. Sir D. Brandis, in a review of the question in 1873, gave it as his opinion that Kanara, Malabar, Travancore, and the Burma Coast from Moulmein southwards, offered the desired conditions for the successful cultivation of *Hevea*. And Sir George Watt, writing in 1890, remarked that all subsequent experience confirmed this view. The point is undoubtedly one regarding which an ounce of actual experience is worth many pounds of theory. But that experience has since been gained. In Ceylon, and in Burma, the earlier experiments took the form of putting out the young plants in swamps and water-holes, in accordance with the advice given by Cross, the explorer who procured the original stock of plants from Brazil. This method was often fatal to them. What the tree wants is merely a moist soil. It is not impossible to grow it in a swamp, but the soil must be mounded up and specially prepared by means of lime, or by gravelling and sanding. Should the site selected contain a large proportion of swampy land, its drainage must also be seen to. H. Wright, in his recent work on Pará Rubber (Colombo, 1906, A. M. & J. Fergusson, publishers)—a book every intending planter should have in his hands—reports a plantation of trees, many with their taproots and a large proportion of their feeding rootlets permanently under water, and yet yielding over ten pounds of rubber per tree

per annum. See Illustration, Plate IV. He notes however that swampy soils, being generally deficient in mineral plant food, require occasional dressing with potash and phosphatic manures. His conclusion thus is that in well-drained land an abundance of water does the trees no harm. It would appear that the cultivation of the tree in such lands is mainly a question of expenditure, but that there is every prospect of the cost being amply recouped.

In this connexion, the question may arise whether it is wise to select for *Hevea* plantations the swampy or muddy banks of the tidal creeks abounding in the provinces of Ilhas and Bardez in Goa. At first sight one would be inclined to think that these creeks exactly answer to the descriptions given by travellers in the Amazon region, notably by Cross, the pioneer of rubber acclimatisation, of the *igapos* around which the greatest number of *Heveas* are (or used to be, before their extinction by bad tapping) to be found in their natural state. But an important distinction has to be drawn. The Amazon in its lower reaches is virtually an inland fresh-water lake of vast extent, finding its outflow to the sea by two main channels which enclose a delta of island flats whose total breadth from north to south is at least 5,400 kilometres (3,350 miles). The northern or true mouth has an enormous bar, and the southern, by which ocean-going vessels pass in and out is 300 kilometres wide from bank to bank. By both these mouths the river discharges such a volume of water that 100 kilometres out at sea, beyond sight of land in fact, the ocean itself is fresh not salt. Thus no tide setting in from the sea is strong enough to make the water in the igapos salt; all that a tide does is to raise the level of fresh water in them. On the Malabar coast, on the other hand, there are no large rivers, and the creeks are always salt or brackish, except perhaps during the height of the monsoon and in places where there is a bar or sand-bank to keep out the sea. Thus it may be taken as inadvisable to utilise the coast mud-creeks for this form of cultivation.

As to other conditions, experience in the Straits Settlements seems to indicate that the non-alluvial soils, especially the disintegration products of red laterite, are good for Pará rubber. Wright notes that in Ceylon soils physically and chemically poor have nevertheless given trees whose yield has been most satisfactory. This ought to be good news for intending planters of the Konkan and Goa, as his description fits much of the area of those regions. It would appear that what may be summed up in a word as *climate* is after all the most important factor in success.

Coming to climatic considerations, then, it is clear that the tree, though often proving a delicate exotic, possesses a certain power of adaptability. Pará, it will be remembered, lies very close to the equator, and the greater part of the Amazon valley—up to and beyond Manãos—only diverges a few degrees from the line. As an extreme case of acclimatisation it may be mentioned that specimens of this tree have come to maturity (but have never flowered) as far north as Mandalay, almost on the confines of the tropics, where the rainfall probably never exceeds 30 inches and the temperature ranges from 35 to 110 Fahr., and experiments are now being undertaken in growing it in the upper rainy zone of Burma, beyond the tropic line altogether. Elevation, too, does not seem to affect it, other considerations being equal. It is reported to have done well on the Aneimalei hills (Madras Presidency) at 3,500 feet, and in Ceylon at 3,000 feet with a rainfall of 70 inches. In Belgaum, with an elevation of 2,250 feet and a similar rainfall, it has grown, but slowly. The young trees at fifteen months after planting do not exceed two feet in height, and are somewhat sickly; in marked contrast to the young Castilloas of the same planting and on the same soil. Possibly the persistent high winds have a good deal to say to the troubles of the plant. A supply of young trees has been sent down from Belgaum to Goa in the present year, part to be put out in delta land at Aldoná, and the rest on somewhat higher ground at

Margão, where there is every reason to hope that they will do well. The tree has indeed already come to maturity in Portuguese India, at Pondá, where one specimen at least is over 25 feet in height at six years of age so that its cultivation there may be said to have passed the experimental stage.

Summing up the available data and applying them to the case in hand, it would appear that the regions *primâ facie* likely to repay cultivation of *Hevea* are those below the ghâts, from sea-level up to 1,500 feet (preferably from 300 feet upwards), along the banks of fresh-water streams, on red or black soil indifferently, and (with the necessary precautions as to drainage, manuring, etc.) on land reclaimed from swamps. Shelter from very high winds would also seem a desideratum.

4.—REPRODUCTION.

This tree usually seeds after its fifth year, and gives on an average 500 good seeds per year. But if seed is insufficient, cuttings may be resorted to. Seed of fair quality, not unduly delayed in transport, should give from 70% to 80% of seedlings. In Ceylon the young plants, in a well-tended nursery, are said to appear within a few days, but my experience of the plant in Burma at least is that they do not show themselves till about the third week. The following notes of an experimental planting in the vicinity of Rangoon in October 1898 may be found applicable to the conditions of Western India in the same latitude:—

Seedlings above ground.	Percentage.	Average height.
2nd week	0 per cent.	
3rd ,,	12 ,,	0′ 4″
4th	27 ,,	
5th ,,	40 ,,	
6th ,,	47 ,,	
7th ,,	48 ,,	
8th ,,	49 ,,	0′ 10″
12th ,,	51 ,,	1′
18th ,,	52 ,,	1′ 8″
24th ,,	53 ,,	1′ 11″
36th ,,	53 ,,	2′ 7″

PLATE V.—Pará rubber-seed; sorting it for export (Ceylon).

These seeds, it should be noted, were received after a week's journey by steamer, packed in sacking without special protection, and may have been laying about for some days in the plantation before shipment. Thus they may be considered an inferior consignment. It is not safe to generalise from a single experiment, but it may be noted that in the current year a planter in Goa, Captain D. Miguel de Alarcão, got results from a first sowing of Hevea much more favourable than the above, the following being the figures for the first four weeks (up to date of publication):

1st week	Percentage 27%	average height	11"
2nd ,,	,, 45%	,,	1'4"
3rd ,,	,, 61·8%	,,	14"
4th ,,	,, 73·7%	,,	16"

The following is an extract from Botanical Circular No. 4 of 1898, issued by the Director, Peradeniya Government Gardens, Ceylon:—

"The germination of the seed is very rapid, and a long tap-root is soon produced. The seed should be sown about an inch deep in well-prepared soil, in nurseries, or if preferred, in bamboo pots or baskets. They should be kept shaded and watered, and when the young plants are from 18 inches to 24 inches high they may be planted out. Good results are also obtained by stumping, the plant being allowed to grow about 3 feet high, then taken up and the main root cut across about a foot below the ground; but the method of planting-out the smaller seedlings is perhaps preferable.

"The plant may also be propagated by cuttings. The method employed in the Botanic Gardens has usually been to taken cuttings near the ends of the branches, but further back than any of the leaves. Each cutting is about a foot long, and is cut off at both ends by oblique cuts made just below leaf-scars. The cuttings are planted in nurseries in wet earth. This method is somewhat precarious; sometimes nearly all the cuttings grow, at other times only a small proportion.

"The seedlings, stumps, or cuttings should be planted out during rainy weather in prepared places. Holes should be dug as in the case of cacao, and filled with good soil. A little manure will often be advantageous. The young plants require to be lightly

shaded for a time until they are established, and probably for the first two or three years they will grow the better for a certain amount of shade, such as would be given by narrow belts of trees running through the plantation. These belts should be arranged to act as wind-belts, as the *Hevea* is easily injured by wind. By the time the trees are about three years old they will have grown up to a height of about 25 or 30 feet and form their own shade."

5.—LAYING-OUT THE PLANTATION.

Assuming that the advice of the Director, Ceylon Botanic Gardens, has been followed as regards the nursery, the next thing to be attended to is the protection of the young plants from their numerous natural enemies (pig, deer, cattle, etc.). This will no doubt have already been seen to as regards the nursery, but it is quite as necessary in the case of the area into which the seedlings are about to be transplanted. The more efficient the fencing, the better for the plantation in the long run. Barbed wire and posts the present writer has not always found sufficient, but when the wire can be supplemented with a substantial hedge of thorny plants it is quite practicable to create in the first or second year of operations an impassable barrier round the property. Unfortunately some of the plants commending themselves most strongly by their thorniness or their rapidity of growth (prickly pear and lantana for instance) have a trick of extending themselves far and wide where they are not wanted and becoming a source of annoyance and expense. The *Acacia farnesiana* (khair-babul) is a useful hedge-plant in its way, but by far the most serviceable shrub, provided it is vigorously pruned so as to make it send up vertical shoots, is the *Carissa carandas* (Marh., *karanda, karewanda;* Kan., *kauli-balli, karekai*). If the land selected contains any trees of the *Careya arborea* (Marh., *kumbya;* Kan., *kawal*), it will be advisable to cut them out before transplanting the rubber-trees, as they attract pig in large numbers when the fruit begins to fall.

In Burma, the present writer found it a good plan to fence in, block by block, the land which each year's nur-

sery stock would fill (planting at stake having proved a failure, as it often does), removing the posts and wires from one side or from two as the case might be, so as to utilise them in fencing the adjoining block or blocks the ensuing year. The hedge planted to supplement the wire was of course left standing, to give the plantation a series of compartments, each with its own enclosure.

Opinions have differed very considerably as to shade for the *Hevea*, the present accepted belief being that it is not only unnecessary but injurious after the tree has attained 20 feet or so in height. But it seems quite clear that the young plants require shelter if not shade—shelter from high winds certainly, and shade from the hot-weather sun, probably, as well. If the trees have been put out on open land after their removal from the nursery, some fast-growing tree should be planted in alternate lines with them at the same time, if not previously seen to. The selection of a suitable nurse for the young rubber will of course depend on the locality, but the *Carica papaya* (Marh., *papaya;* Kan., *perinji*), the *Erythrina indica* (Marh., *pangara;* Kan., *mullu mutala*), and the *Moringa pterygosperma* (March., *shevgi;* Kan., *nuggi-mara*) may be cited as a good selection. When they have served their purpose as shade-trees, their leaves and young branches can be made use of as green manure, the trimmings from them being forked into the soil round the roots of the rubber-trees. A variety of *Erythrina* known in Ceylon as Dadap (*E. lithosperma*) is of special value, as it returns valuable elements to the soil without abstracting from it too much of the nutriment required by the *Hevea*. The intervals recommended, if this course be adopted, will be 20 feet by 20 feet for the *Heveas*, and 20 feet by 10 feet (or 20 by 5 feet if the papaya be used, as it does not branch widely) for the shade trees. That is to say, assuming the lines to run north and south, which will be found convenient whenever possible, every second shade-tree in the line (if the 20 feet by 10 feet interval be

adopted) will be due east of one rubber-tree and due west of another (except of course on the outer lines of the plantation), the intervening shade-tree, or trees, as the case may be, standing so as to ward off the rays of both the morning and evening sun when its course declines from due east and west. For vertical protection at noon-day, the tree may if necessary during the extreme hot weather have a temporary shelter of jungle leaves, but as a rule this will not be found necessary except for a few days after transplanting from the nursery. After the young tree has quite recovered from its move into its new site, and has put forth new leaves and shoots, but *not* before it stands about eight or nine feet high, the terminal bud should be pruned off so as to induce the tree to branch out laterally and at the same time form a stouter stem. This is an important operation, and one requiring some discretion. Its effect of course is to stop the vertical growth of the tree, and it is undesirable that this should happen before the planter has a sufficient tapping surface on the stem. The brown bark should not merge into the green at a height much lower than seven or eight feet.

Another point to be borne in mind is that in the earlier year of the plantation the ground should *not* be cleared of protective covering (even sensitive plant is better than nothing). When the trees have spread out in the crown so as to give good overhead shade, any scrub remaining may be cleared at the end of the hot season, and at once burnt and the ashes spread over the soil round the roots of the tree so that they may be washed into the soil with the first rains.

The holes into which the young plants are to be placed should be on a liberal scale. Bearing in mind the rate of growth of the feeding rootlets, a pit 3 feet diameter at ground level and 2 feet deep, narrowing to 1 foot at bottom will not be too big. It may be filled with a mixture of surface soil and leaf-mould or well-rotted stable litter, then filled up with the earth dug from it so as to form a mound about 2 feet high, on top of which the young plant should be

PLATE VI (*a*).—Process of thumb-nail pruning for Pará rubber.

(*b*).—Process of thumb-nail pruning for Pará rubber. Note system of draining the land.

put, the utmost care being taken not to allow the tap-root to get bent in the operation. It may be thought that this method will send the feeding rootlets out till they emerge on the outer slopes of the mounds and suffer from exposure to the air. But practically this cannot happen, for in the first rains the mound gets washed down to a great extent, and also sinks as the earth of which it is composed settles. The circular trench formed around it by the original edge of the pit should be filled from time to time with green manure and ashes of freshly cut wood. In the second and third years this circle should be widened and manured similarly, at a radius corresponding with the presumed growth of the rootlets, which require the nutriment at their tips. By the fourth year, if the trees have grown as they should have, all the shade trees remaining may be removed, as the crowns of the rubber planted 20 feet by 26 feet should be ready to meet. But, having regard to the ever-present danger of general disease in plantations formed of a single species on a large scale, it will be found of advantage to sacrifice a certain amount of culturable area and devote it to trees other than those forming the staple of the estate. Not necessarily trees altogether unprofitable; but preferably trees of a species remote from that of the main crop. In the case of an entirely new plantation this can be arranged for in the design of laying-out. The method suggested for the Burma Government plantations and exemplified on the Kambé experimental rubber-farm, Rangoon, was to form units of 300 feet by 300 feet (or slightly over two acres each), and to demarcate these either by five-foot paths crossing one another at right angles, with rows of leguminous or other trees on either side forming avenues, or by leaving belts of the original jungle standing and running fences through these so as to form compartments. These avenues or belts were intended to afford the included rubber-trees a sanitary cordon, so to speak, in the event of parasitic or other disease making its appearance in any neighbouring block.

For planting in Goa, the principle of the arrangement will hold good, *mutatis mutandis*. The 10 feet by 10 feet dimensions cannot be conveniently translated into metrical terms, but a workable method would be to take either 2·5 or 5 metres for the 10 feet unit, 5 or 10 metres for the 20 feet one, and so on. The former of course gives somewhat closer planting, the difference being about 0·2 metre per ten feet English, but either scale has an obvious advantage in the computation of the hectare, which in its turn corresponds approximately with the 300 feet by 300 feet block unit just described. The wider the interval, as a general rule (up to a reasonable limit of course), the better. The question of mixed plantations will be reverted to in the summary of data and results, at the close of the notes.

Roads, paths, sheds, fences and drains are matters depending for the most part upon local conditions, and their provision must be left to the individual planter's discretion. Swampy lands want draining and heaping-up of the earth so as to give the young trees dry soil to start upon; hill slopes on the other hand require contoured drains to prevent the formation of *nalas* and the washing away of the earth necessary for the trees themselves—terracing too has to be attended to. But these are matters of general application, not confined to the case of a *Hevea* plantation alone.

6.—HARVESTING.

Several questions have here to be examined, the most important being: when to begin tapping for rubber; how to tap, and how *not* to tap. Dr. Willis (Peradeniya Botanic Circulars) advises us that no tree whose girth (at the height of a man's eye from the ground) is under 2 feet should be tapped at all. That girth is seldom attained under six or seven years of growth. Other authorities consider that no tree should be tapped until it has fruited at least once—which comes to much the same thing. Both would seem sound rules, in the interest of the tree

PLATE VII.—Pará rubber-tree, shewing half-spiral tapping.

itself as well as of its product, very young rubber being as a rule much less springy than the matured article, and less abundant in the latex. But they have received considerable modification in the light of recent experience, the doctrine now coming into favour being that the young tree requires to be trained to yield latex, and nothing is gained by waiting till it matures.

There are many systems of tapping, some of which are effective as regards extraction of rubber but injurious to the tree itself, and should only be used when it is intended to tap the tree to death (so as to thin out a too closely-planted rubber-grove and, at the same time, lose none of the possible yield). Of these, the full spiral curve is perhaps the most effective. It consists in making a channel from a point at a convenient height on the stem (there is not much to be gained by tapping higher than a man can reach) and winding it round the stem so as to guide the latex down to a cup or tin fixed at the root of the tree. The following extract from the *Times of Ceylon*, quoted by H. Wright on p. 63 (2nd Edn.) of his book on *Hevea brasiliensis* describes the operation :—

"The first cuts are made each a foot above the other, and in the case of a tree 18 inches in circumference the groove would go nearly round the stem. For trees 30 inches in circumference two lines of cups on opposite sides of the tree would be required, and a tree 54 inches in girth would take three lines of cups. The first cut is made with a knife used much like a plane; and the second knife is used thereafter day by day for paring off the edge of the groove originally made. One month's tapping with the original knives made the grooves 2 inches wide, so that the whole bark would be cut away in the course of the year's work, assuming that the tapping were carried on throughout the year in alternate months. The cutting face of No. 2 knife, however, has been reduced to the 16th of an inch. This reduces the bark area cut away in a month from 2 inches to 1 inch. A third instrument has been invented for use in this process. It is in the form of a circular pricking instrument, which is used to penetrate to the cambium at the edge of the previous cut. This is done alternately with the cutting, and is believed to free the inner bark from any accumulation of latex."

"This method was systematically begun in October 1904, and the group of trees has since averaged over 2 lbs. of rubber per tree for each month's tapping, and those trees which have been tapped hardest have produced 16 lbs. each in twelve months. Although these trees, like the rest, were tapped in alternate months at first, with rest in November and January, they were continuously tapped from February, right through the drought, up to early in June. Then it was found that the yield was falling off, and they were rested for some time. Tapping was recommenced in September. None of them shows signs of drooping, and as further token that new and handsome figures in Ceylon yields are not confined to a few trees, records were produced which showed that the whole of the 255 trees on the estate of tapable age had yielded an average of 4 lbs. per tree in the eight months, without the trees becoming harassed. A platform is to be erected round some of the trees for tapping higher up; and an average yield of 3 lbs. per tree is expected at from 6 feet to 10 feet from the ground."

These experiments indicate that tapping may be carried on at almost any season of the year except the heavy rains. It is a tradition of the Amazon rubber-gathers not to tap a tree when in flower, and this may be a safe rule to follow, but in other respects the Amazon *seringueiro* is not a model for imitation. His tapping almost invariably injures the cambium and heart-wood of the tree, which even the vigorous treatment above described avoids doing.

Another and a much gentler method is the modified herring-bone system, by which oblique cuts are made V-shape one below the other from the same height as in the spiral system, the apices of the V's being then united by a channel formed by luting on to the stem two parallel strips of clay, so as to conduct the drip of latex down to the cap at the foot of the tree. But for a full description of these and other methods, and of the means used for keeping the latex fluid (*e.g.*, by the addition of alkalis, ammonia, formalin, *etc.*), till it can be coagulated in bulk, reference must be had to the work of Mr. Wright, cited above.

In the earlier days of rubber-planting in Ceylon, these results in rubber-gathering were not foreseen. Dr. Trimen's

estimate, based upon experiments extending from 1888—1896, showed an average of only 1½ lbs. of rubber per tree per annum from the 12th to the 21st year. Thus upon a plantation of 50 trees to the acre (30 feet by 30 feet intervals) the yield would be about 90 lbs. per acre per annum, a figure insufficient, at rates then ruling in the produce market, to give the planter an adequate return to capital. It was felt, however, that the case had not been sufficiently studied to justify a condemnation of rubber-planting, and subsequent experiments have proved that much better things were possible. Younger and more closely planted (300 to the acre) trees were put under observation, and gave actual results of six consecutive weekly tappings at 97 lbs. per acre, with estimated results for the year, had three or four more tappings been made, *after giving the trees a few months' rest*, at about 120 lbs. per acre.

In prescribing a few months' rest, however, the experimenters found that they had failed to take into account the most important factor in the case, namely the *wound response*. Travellers in the Amazon regions had mentioned the natural phenomenon as familiar to the Brazilians engaged in rubber-gathering; these men took it for granted that a tree tapped for the first or second time could not be expected to yield freely. It had, as they phrased it, to get used to tapping. Hence they persisted in working at each tree until he had extracted day by day all it was disposed to yield them. This point was then carefully studied in Ceylon, with very remarkable results.

The physiological explanation is to be found in the cellular formation of the laticiferous vessels. The first wound, by drawing off the fluid contained in the sacs actually penetrated, causes the rupture of the immediately superior sac-walls by gravitation of the fluid towards the vacant cells, and the formation of a series of ducts in place of the independent but adjoining sacs. By repetition of the wound, or better still by the more re-opening of its

edges, more and more latex is extracted, causing the gravitation of more and more fluid from above and around to take its place, and thus extending the tubular system over an increasing area of the space between the bast and the cambium.

Once this fact was grasped in its true significance, it was seen that the principle of giving the tree a prolonged rest was a mistaken one, exactly the contrary being the sound method. The following figures are given by Wright (Op. cit., p. 70) as arrived at by Willis and Parkin in their later experiments :—

Number of Tappings.	Number of Incisions.	Date of Tapping.	Yield of latex in centilitres.
1st	40	March 25	61·0
2nd	40	30	105·5
3rd	40	April 6	220·0
4th	40	12	208·5
5th	40	15	255·5
6th	40	20	290·0
7th	40	25	276·0
8th	40	May 1	253·0
9th	40	6	264·5
10th	40	13	275·0
11th	40	20	255·0
12th	40	26	262·0
13th	40	June 1	328·0
14th	40	6	449·0

The conclusions indicated by Arden's (Straits Settlements) experiments in the same direction were that incisions should as a rule be repeated every 24 hours, and that the amount of additional latex obtained by making them on alternate days or weekly was not in proportion to the period of rest given the tree. His figures were these—

60 incisions made on 6 consecutive days gave 99½ lbs. wet rubber.
60 do. do. 2 days' interval gave 111 lbs. do.
60 do. do. 7 days' interval gave 104¾ lbs. do.

These data should be sufficient for guidance as to the most successful modes of working, but local and climatic

PLATE VIII.—Pará rubber-tree, shewing half-spiral tapping, with knives and cups for collecting latex.

conditions may render it advisable to modify them for Western India. Mr. Arden, from his observations in the Malay Peninsula, is inclined to believe that the yield of latex in the case of the *Hevea* is greatest when the tree is resting, so to speak, *i.e.*, when it is leafless. But his experiments, he explains, cannot be regarded as conclusive, as he has not been able to continue them over a sufficiently long period. Cibot, speaking from experience of Bolivia, inclines to the same view, but thinks that the increased yield will be found so slight as to be negligible from a practical point of view. The season when obviously all tapping should cease, he remarks, is that of the heavy rains. This is a matter which will have to be largely determined by local labour conditions. The planter's harvesting season, if economy is to be studied, must as a rule coincide with the village cultivator's slack time, otherwise the large temporary establishment of men and women coolies required will not be forthcoming.

In dealing with the question of the conversion of latex into rubber, one circumstance should not be overlooked, *viz.*, that the coagulum immediately obtained from the fluid latex is still a wet rubber. Between a wet rubber and a rubber chemically dry there is a wide difference, but it is neither necessary nor desirable that the rubber of commerce should be absolutely water-free. M. Cibot (*Journ. d'Agric. Trop.*, April 1905) has recorded an interesting and useful series of observations upon the various stages of transition. His first study was the case of a litre of *Hevea* latex, gathered in April 1897. The weight of the fluid was

	975 grammes	or about 2 lbs.
In August 1897 it weighed	625 grammes,	showing a loss of 36 %
In August 1902 „	550 grammes,	„ „ 43 %

In October 1904, a piece of the same specimen, dried in an oven for three days at a temperature of 110°C

(230° Fahr.), showed a further loss of only 0·29 %. The original specimen, it should be noted, had been coagulated by the Strauss process, *i.e.*, with alum—a method not to be imitated, as it gives an exceedingly wet rubber.

A second lot of latex, weight 8 kg. 900 grammes, was smoked on June 21, and showed loss as follows :—

Weight on Coagulation.	Loss on Latex.	Loss on Coagulation.
8 kg. 300	7 per cent.	
22 7 ·050	20·7 „	15 per cent.
23 6 ·550	26·4 „	21 „
24 6	32·5 „	27 „

His third experiment was with a big ball, composed of 23 days' collections of latex, smoke-cured from day to day between the 19th July and the 25th August. Its weight when fluid was 108 kg. 240.

On the 25th August it weighed 73 kg., being a loss on the latex of 30 per cent.
2nd September „ 66 „ „ „ 39 „

These figures have an important bearing on the calculations of the planter, as of course the volume of the marketable rubber is much less than that of the newly-formed coagulum. An average allowance of about 35 % for loss in drying might be made in the case of a healthy lot of trees.

7.—ESTIMATES OF OUTLAY.

Most of the published estimates for raising Pará-rubber relate to Ceylon and the Straits Settlements, and they vary from Rs. 183 per acre up to the 6th year (for light low-country jungle land) to Rs. 366 per acre up to the 10th year (for forest land). The former estimate, with a number of others intermediate between it and the latter, to suit varying conditions of soil and climate in Ceylon, will be found in the Appendix to Wright on *Hevea*

brasiliensis. The latter estimate, that of Mr. F. Lewis, Conservator of Forest, Colombo, published in the Kew Bulletin of October 1898 (No. 142) may be given here *in extenso* as applicable, with certain modifications, to Indian conditions :—

Felling and clearing, @ Rs. 12 per acre ...	Rs.	3,600
Lining 10 by 10 ft. @ Rs. 2 per acre ...	,,	600
Holing, @ 75 holes per cooly @ 40 cents (As. 6 : 8)	,,	697
Filling, planting, and carrying plants from nursery to holes, 300 per cooly @ 40 cents ...	,,	175
Draining, 300 ft. of drains per acre at 1 cent per running foot	,,	900
Lines for coolies: 1 shed of 10 rooms of 12 by 10 ft.		800
Roads for inspection, 2 miles ...	,,	160
Plant nursery, including watering ...	,,	150
Weeding, @ Re. 1 per acre per month ...	,,	3,600
Cost of surveying lines round plantation, say	,,	75
Contingencies, such as special work, bridges over stream or supplying vacancies, etc. ...	,,	250
Salary of Assistant	,,	1,000
Tappal cooly	,,	120
Tools	,,	300
	Rs.	11,927

The Conservator adds :—

"This represents an average of Rs. 40 per acre. A return of Rs. 4,200 is estimated to be obtained by the sale of timber and firewood from the land cleared. This should suffice to erect the Assistant's bungalow and leave a small margin for contingencies.

"To this estimate private planters must add the cost of land and of seed (about Rs. 20 per 1,000). These items will probably make up the total cost for the first year to at least Rs. 125 per acre. As a matter of fact 300 acres is more that can be opened in one year, as the number of seeds required will be at least 160,000, or nearly two years' crop of the trees in the Botanic Gardens."

For the second, third and fourth years, Mr. Lewis estimates the expenditure on weeding and supplying @ Rs. 12, 8 and 5 respectively. Assuming that the

expenditure in the years following is at the rate of Rs. 5 per acre, the cost of the plantation up to and including the tenth year might work out as follows:—

"Cost of land, 300 acres @ Rs. 75	...	Rs.	22,500
Cost of seed, say	...	,,	3,600
First year's cost, as above ..	...	,,	11,927
Weeding and supplying, 2nd year ...	...	,,	3,600
Do. do. 3rd ,,	...	,,	2,400
Do. do. 4th ,,	...	,,	1,500
Do. do. 5th to 10th year, inclusive	...	,,	9,000
Salary of Assistant, 2nd to 10th year, inclusive	...	,,	9,000
Tappal cooly and tools, 2nd to 10th year	...	,,	1,250
		Rs.	75,777

"Allowing interest at 7 per cent. on all money expended up to the end of the 10th year, outlay on the plantation will amount to at least Rs. 100,000, or Rs. 366·66 per acre."

CHAPTER III.

CASTILLOA ELASTICA.

1.—DESCRIPTION OF THE PLANT.

THIS tree is one of the Artocarpaceæ, Natural Order Urticaceae, to which the bread-fruit tree and the common jack-tree of India belong. Recent writers (O. F. Cook, New Species of the Central American Rubber-tree, Washington, U.S.A., 1903; H. Pittier de Fabrega, Sur les Castilloa du Costa-Rica, *Journal d'Agriculture Tropicale*, January 1905) describe at least eight distinct species of *Castilloa*, not to mention varieties of that which they designate *C. elastica;* hence it is not easy to reconcile the descriptions given of the tree by different authorities. Chapel (le Caoutchouc et la Gutta-percha, Paris, 1892) says it ordinarily grows to a height of 12 to 15 metres, with a diameter at base of one metre. According to Sir D. Morris, it is, when fully grown, of an imposing height, specimens having been met with 160 to 180 ft. high, with a stem 12 to 15 ft. in circumference. In its native forests the tree only branches at the crown, where it forms a canopy of foliage 40 or 50 ft. in diameter. Its roots are in proportion—the taproot long, and the feeding-rootlets addicted to straggling far and wide. The diameter of the trunk varies according to the species or variety described—from 2 ft. to 5 ft. Most writers agree that its bark is smooth, but differ as to its colour. Rowland W. Cator, in an article much quoted at the time (by promoters of rubber-companies—1896-97), gives in Chambers' Journal a graphic description of the collection of its latex from the forests of Nicaragua; and he says it has a dark slate or ash-coloured bark. Koschny, a planter of Costa Rica, has communicated to the *Journal d'Agriculture Tropicale* (July 1901) a careful study of three varieties of *C. elastica* and of a *Castilloa* he designates

Tunu and condemns as worthless (this cannot be the *C. tunu* Hemsley, as it is unquestionably a good rubber-tree). Koschny's three varieties are the white, the black and the red, distinguished by the colour of their bark alone. Of these, the only one likely to repay cultivation is the white. Seen from a distance, he says, the trunk shows glimmers of white and red, and the white colour is due to a very fine white lichen upon it. The tree now grown in Ceylon and India has a smooth soft greyish-brown bark, covered on the young branches with a light-brown tomentum. The leaves are from 12 inches to 18 inches in length, oblong, cordate at the base, dull-green, the under surface having a velvety pile of short brown hairs. The edges of the leaves are entire, though apparently dentate owing to tufts of hair growing out of them. According to Pittier de Fabrega, Koschny's distinctions are not fixed forms but merely variations of type purely accidental, due perhaps to environment, perhaps to individual peculiarities.

A striking characteristic of this tree is its habit when young of forming temporary branches which it sheds from time to time during its first four or five years of life. The pseudo-branches grow out at an angle of 45 to the stem, pointing upwards, and by degrees bend till they stand out at right angles to it. They then continue their declension till they finally snap off, leaving the stem scarred at the point of severance. The true branches, which are woody and start from buds in the axils of the flat branches, do not form until the tree is ready to flower. Its flowering is somewhat capricious—it sometimes occurs in the dry season, sometimes in the wet, and one tree will produce in one year a profusion of male flowers, the following year nothing but female flowers.

The fruit-mass is composed of eight or ten conical fruits ranged side by side on a disk formed by leaf-scales set one over another, bright scarlet in colour, not unlike small tomatoes in appearance. The seeds are white like ivory, about the size of a pea, and very perishable.

PLATE IX.—CASTILLOA (FULL-GROWN) AT 1,570 FEET ELEVATION IN CEYLON.

The flowers are male and female on the same branch, disposed on receptacles flat or reniform surrounded by bracts forming involucre; the male flowers comprise a large number of stamens without perianth; female flowers in numerous glomerules, on a common receptacle; calyx tetramerous, ovary single, fruit first drupaceous, afterwards hard and dry.

The controversy as to whether the tree imported into Ceylon and thence distributed for cultivation over the Eastern Tropics is the best variety of *Castilloa* does not seem to have been definitely settled. The point is one of considerable importance to the planter, for as M. Vilbouchevitch, the able Editor of the *Journal d'Agriculture Tropicale* remarks by way of preface to an article in that paper written by M. H. Pittier de Fabrega, of Costa Rica, "not to interest oneself in it is to expose oneself to the risk of planting something else than one intends, and to spend one's money and labour in vain." We might instance a case within the last ten years where a pubic Company, with a nominal capital of over £400,000 came to grief mainly through acquiring for an enormous sum a tract of territory in Mexico covered by wild trees closely resembling *C. elastica* in every respect except that their latex contained no caoutchouc.

On this point Dr. Willis (Annals of the Royal Botanic Gardens, Perradeniya, October 1903) observes:—

"*C. elastica* is usually described as a large tree of rapid growth reaching 180 ft. in height and 15 ft. in girth. The Ceylon plants show no sign of such growth. There has been some doubt as to whether they are the true *Castilloa elastica*; they were brought by Cross from Darien (Panama) . . . Recent research seems to show that this form cannot be specifically separated from *C. elastica*, but at the same time it is not improbable that the latter occurs in several different varieties. . . In recent years some seed has been imported direct from Mexico and elsewhere, and may prove to be different from the originally imported form."

M. Koschny, the Costarican planter to whom the controversy is mainly due, states that a number of native experts

in rubber, sent by him to Java at the request of a Dutch planting company, report that the Castilloa grown on the plantations there is a variety entirely unknown to them in Costa Rica as a rubber yielder. He accordingly obtained from Java samples of the rubber produced by the tree, and found it to correspond closely with that obtainable from the *Castilloa costaricana* Liebm., a comparatively worthless tree growing in Central America at elevations between 1,000 ft. and 3,000 ft. As all the Castilloa in the east has been obtained through Ceylon he argues that the latter island is responsible for the propagation of two valueless species—*C. costaricana* and *C. Markhamiana* (Panama-rubber). The *Journal d'Agriculture Tropicale* however (issue of July 1903) hesitates to endorse this theory, as it does not square with the experiments in coagulation of Castilloa latex effected at Peradeniya (Ceylon) and Buitenzorg (Java); nor with the practical results obtained in the exploitation of the tree at Pamanœken and Tjasem, near Sœbang (Java).

Quite possibly the earlier lot of trees, those from Panama, may not have been as valuable as those obtainable elsewhere. However it is only right to note that as far back as 1882 a sample of rubber, extracted from one of the 1875 consignment of Panama trees sent through Kew to Ceylon, was submitted for professional examination to an expert nominated by the Kew authorities, and he reported it as worth from 2/9*d.* to 3/ per pound—a price not far short of that then ruling for Fine Pará. The note published by Mr. A. C. Matthew, of Moneragalla, Ceylon (Tropical Agriculturist, July 1905), describing a process by which he has succeeded in extracting from his trees a rubber valued in the London market higher than that of the *Hevea*, evidently refers to trees of the latter consignment. Whatever doubt may still exist in Ceylon, the authorities of the Royal Botanic Gardens in Trinidad appear for some years past to have satisfied themselves that the *Castilloa* so extensively grown in that

island is the best kind, and from the proximity of the colony to Venezuela as well as to Central America, *i.e.*, to the natural habitat of the plant, it is quite safe for the planter to conclude that supplies obtained through Trinidad may be accepted without further question. In 1898-99 the Superintendent there reported a large stock of seedlings available. I have not seen later reports, but presumably that statements of that year hold good up to date.

2.—NATURAL CONDITIONS, HABITS, ETC.

The natural range of this tree is from 6 S. Lat. to 21 N., and from sea-level to 1,500 ft., principally by river banks, under the most varied conditions of soil, humidity, and temperature. A writer in the *India-rubber World* (February 1900) says :—

"I have rarely seen native trees much above 1,200 ft. In the humid Tropical zone of Mexico they are found in greatest number and vigour between sea-level and 1,000 ft. This zone includes portions of the States of Vera-Cruz, Oaxaca, Chiapas, and Tabasco. With few exceptions the climatic conditions necessary are found only upon the Atlantic or Gulf side. Here the temperature ranges in summer from 73 to 96 Fahr., and in winter from 55 to 86. The rainfall varies from 65 to 130 inches per annum, fully 2/3rds of it falling between June 1 and November 1, the balance being distributed in light showers from the latter date to March 1, after which the dry season proper commences. Such in brief are the natural conditions under which this variety of rubber seems to flourish."

Speaking of the preference of the plant for sun or for shade (a much contested point among planters of Castilloa), the same writer says :—

"Lately rather a strong article was published by a resident of the Pacific side of Guatemala, taking the ground that trees suffered from sun exposure and gave but little sap. I think locality will be found to have much to do with this. It is well known that most of the Pacific Coast of Mexico and Central America is hotter and drier than the Atlantic Coast at like elevation. My own observation has been that on the Atlantic side of the Isthmus of Tehuantepec the tree grows in full sun with astonishing rapidity and vigour. Trees can be seen there that have attained a height of 10 ft. in 2½ years from seed, have a diameter of 4 inches, and bleed copiously when incisions are made. It is proper to state

that these results are in the case of trees in the best soils rich loams, with ample drainage. Under such conditions trees of this age have flowered and borne seed. . . Hundreds of old trees can be seen about the villages of Acayucan, Malota, and Oluta, and around the coffee estates, which have for years been standing in full sun without ill effect.

"As to soils, the *Castilloa* can be met wild in a state of nature in pure black loam, light sandy loam, alluvial soils, and in dark soils mixed with gravel, but never in ill-drained soils nor in swamps. The best soils are undoubtedly the richer loams, slightly sandy. Here, if the drainage is good, the *Castilloa* will be at home, and the summits and slopes of low undulating hills of this formation produce quite as good trees as the bottom lands."

3. LOCALITY FOR PLANTING.

As a general rule, *Castilloa* will grow wherever coffee or cacao grows. It is essentially a tropical plant, but has a much wider natural range than *Hevea brasiliensis*. As we have already seen, it seems to prefer a climate where the dry season does not exceed three or at most four months of pronounced drought. The present writer has however grown it successfully in the vicinity of Rangoon as well as in the Belgaum District of Bombay Presidency, both of them places where a heavy monsoon rain of from four to five months is followed by seven or eight months of almost rainless weather, with the addition (in the former case) of about three months of very fierce sunshine, unbroken by cloud or shower. Of course young plants under these conditions require watering, and may be the better of shade for the time of greatest heat.

As regards elevation, *Castilloa* has been found to yield rubber up to 2,400′ or 2,500′, provided the climate is moist or there is irrigation, natural or artificial, to compensate for any deficiency of rainfall. Its habit of forming a long tap-root would indicate a preference for deep rich soil, but we learn from a practical planter (Mr. H. H. Lewis, General Manager of the Mexican Gulf Agricultural Co.), whose views are endorsed by the *India-rubber World* (New York, July 1899), that *Castilloa* does not necessarily

require as rich ground or as much moisture as does coffee, but it is fully essential that the land be well drained, for "wet feet" are as injurious to one as to the other. Mr. Lewis adds:—

"I have seen young rubber apparently doing well upon land practically exhausted by tobacco; likewise on land heavy with clay, and again on soil consisting almost entirely of sand; but I have never seen it growing on wet land, or *old* trees bearing well on anything but what had been rich friable virgin forest land at the time the trees were put out."

With reference to the concluding remark, it may be mentioned that reports from Ceylon go to show that Castilloa refuses to grow *at sea-level* after reaching a height of 10 to 15 ft. (*i.e.*, its normal height in the second or third year of growth). But this I suspect is true only in the literal sense of the words. The only kind of rubber that will grow anywhere near the level of the sea, that is to say on or close to the shore, is the *Parameria glandulifera*. If the report means, say an elevation of 50 ft. above sea-level, there are facts pointing both ways. Some confirmation of the statement might be drawn from the behaviour of the Castilloas imported into Burma about twenty years. From the consignment of this plant brought by Cross from Panama in 1876 (the tree as to the economic value of which the discussion above referred to has arisen), some half-dozen specimens were passed on to the experimental gardens at Margui, and put down in forest land through which a tidal creek, the Bok-Chaung, runs. No note appears to have been taken of the progress of the trees, but in 1896 we found two surviving, although planted in a swamp. They were then 15 ft. and 18 ft. respectively in height, apparently in fair health, but devoid of leaves except at the crown, and with stems slate-coloured, almost black, covered with pits or scars where the pseudo-branches had dropped off (showing that the trees had followed their normal course of growth). Next year they both sickened, for no discernible reason, lost their crowns, and one of them died. By 1900, on our third inspection

The pulp fermented and turned sour, ruining the seeds. Other seeds were packed separately in paper and placed in boxes. They proved a total loss. Then he separated the seeds from the pulp and dried them slowly in the shade, but mould sprang up on the pieces of adherent pulp and caused a heavy percentage of loss. Finally he hit upon an effectual method, which he describes thus:—

"I first selected fine specimens of fresh seed—for all are not of the same size, and do not produce equally vigorous plants—being careful to separate from them any that had sprouted or showed signs of decay. They were then cleaned carefully by washing away the particles of pulp in cold water. The cleaned seeds, looking like little nuggets of ivory, were spread on cloths and allowed to dry in a cool room for six hours. They were then packed in sand, just damp, but nothing more, with which had been mixed wet charcoal in the proportion of 10 or 15 parts to 100 parts of sand. The object of the latter was the checking of fermentation and mould. The sand, by the way, was carefully washed before use. About 1,000 seeds were packed in a tin box 4 x 8 x 2½ inches in size, but they were rather crowded; 500 seeds to the box would have been better. In packing the seeds, I first laid a piece of flannel at the bottom of the box, then spread a layer of sand and charcoal, then a layer of seeds, covering them with more sand and charcoal, being careful that none of the seeds should touch the sides of the box. I found while transporting the seeds that in boxes where the sand was overdamp heating had set in, but this was checked by making holes in the lids of the boxes to admit the air. In these cases there was some loss ultimately. My experiments in Costa Rica have proved successful on the whole, since I have tens of thousands of young rubber trees as a result of bringing seeds from Costa Rica. This brief record is offered here for the reason that the same methods may prove valuable in other cases. The principle on which the whole is based is that the packing of the seeds for long journey must be designed to assist nature in protecting the seeds, or perhaps to provide them with surroundings for their protection which because of their super-abundance nature has left unprovided."

Having got the seed safe and sound as far as the plantation, the next step will be to raise a nursery. This is not a tree to be sown *in situ* and left to its own devices. The following suggestions, offered by

PLATE X.—Young Castilloa at Belgaum, planted at 20 feet by 20 feet intervals.

Messrs. J. P. William & Bros., of Heneratgoda (Ceylon), seems practical :—

"Seeds should be grown in ordinary shaded nurseries prepared in rich soil. If the soil is poor, cowdung manure should be added (1 part to 3 parts soil). Put the seeds 6 inches apart, one inch under surface; water once a day in the evening, and the seeds will germinate in four to six weeks. When the plants are six inches high remove to baskets filled with rich soil, or soil mixed with cowdung manure; when they are well established in the baskets plant out in rainy weather, with the baskets, 15 ft. apart, in holes 3 ft. deep and 2 ft. wide, filled with rich surface soil. Shade with branches of jungle trees. Plants one and half to two years old may be stumped and planted in the same manner as Pará."

To this may be added the caution given by M. Godefroi Lebeuf, a nurseryman of Paris, who has devoted himself specially to the propagation of rubber-plants of all kinds :—

"Seeds of *Castilloa* often arrive ready to germinate, or already germinated. The first young shoots often rot off on the way, but new sprouts spring out from the base of the cotyledons to take the place of the originals. The planter who gets a case of germinated seeds or of young plants should open it carefully in-doors, so as to avoid the influence of open air. The seeds or young plants should be at once dibbled into the soil an inch or 2 part, in boxes, and cautiously exposed to light and air little by little. After a few days the healthy plants may then be put out in the open air. Full-grown *Castilloas* can do without shade, but young ones not."

The same authority goes on to say :—

"Seeds received before germination has set in should be sown in furrows 2 inches deep and 8 inches apart. They come up very quickly when the plants have reached 1½ ft. in height; the intelligent planter will be able to cut the head of each and stump it in segments of bamboos buried side by side in the ground up to their edges. These stumps would be covered with a cloth so as to prevent the evaporation which would cause the leaves to fade, or if necessary half the limb of each leaf may be cut. It is advisable not to plant these stumps in the bamboo segments for a few hours after cutting, until the latex has dried on the wound. The young plants thus beheaded will soon put out fresh shoots."

Cuttings from the true branches, *i.e.*, those which appear for the first time after the fifth year and are woody,

generally succeed well but it is almost impossible to form trees from the false branches. To increase the number of branches on the tree itself, and thus the number of available cuttings, all that is necessary is to pinch off the terminal bud, when a number of lateral branches will develop themselves. The process known in India as *gutti* (marcottage) may also be resorted to, and is generally successful. But there is not much object in reproducing from cuttings, seeing that at the earliest age when cuttings can be successfully obtained the tree is seeding, and reproduction from seed on the spot is not open to objection on the score of difficulty of transport, whereas the mutilation of the tree by the lopping of its branches is inartistic and to be deprecated.

The fresh seeds run to about 1,000 to the lb., but they dry up so fast that after three days' exposure they will be found to weigh 1,500 to 1,800 to the lb., and when that is the case, their germination is very doubtful.

5.—LAYING-OUT THE PLANTATION.

Much that has been said as to the mode of forming a plantation of *Hevea* is applicable to the case of *Castilloa*. The main differences to be borne in mind are :—

(i) *Castilloa* is a larger and quicker-growing tree than *Hevea*, hence its crown and feeding rootlets require more space ;

(ii) Its stem requires lateral shade after the third or fourth year, which *Hevea* does not so urgently demand ;

(iii) It lives longest and yields most when grown on newly cleared forest land. This may be true of Hevea as well, but we have not found it recorded as a *sine qua non* of cultivation of that tree, as has been stated regarding *Castilloa*.

Although *Castilloa* in Mexico and Central America has remarkably few enemies, one cannot safely presume on its immunity in this country. Exotics of most kinds introduced into India rather tend to go to extremes—if they do not run wild and prove a pest themselves, as in the case

of Lantana, they remain delicate or thrive for a time and then succumb to some pest innocuous to native plants. Especially so when cultivated to the exclusion of other species. However, the chief enemy of *Castilloa* in this country, as far as my experience goes, is the field-mouse or rat, which attacks the roots of young trees soon after planting-out. But such is the vitality of the *Castilloa* in favourable situations that if the mischief be detected in time and the plant removed to a pot or a basket for a while, there to be nursed up, it almost invariably starts afresh, little the worse of losing half its tap-root. But with regard to the ever-possible danger of disease or parasitic and other enemies going for a plantation wholesale, we are inclined to advise mixed plantations. Our views and suggestions will be found in the general summary of the subject, forming the second last chapter of these notes.

6.—HARVESTING.

In dealing with this matter, it has to be borne in mind that *Castilloa* differs from the other important rubber-trees as regards its laticiferous system. In the *Hevea* and *Manihot*, the milk-vessels are confined to the layer of bast beneath the bark, and are not continuous but interrupted by transverse partition walls, whereas in the Castilloas, although most of the vessels will be found in the bast or cambium layer, many apparently large ducts run vertically through the heart-wood and form exudations around the pith. These vessels are continuous, and both in the bast and in the wood they run vertically with very little anostomosis—none being discoverable between the former and the latter. The microscopic aspect of the caoutchouc cells in the latex too is different (a point which it is supposed affects the question of suitable methods for coagulation), those of the *Hevea* being oval and pointed at one end, while those of *Castilloa* are round and of various sizes, the latex from the trunk furnishing larger cells than that from the younger portions of the tree.

Another peculiarity is that the bark of the *Castilloa* is much rougher and thicker than that of the *Hevea*, and varies in different parts of the tree. This renders most of the implements invented for tapping Hevea unsuitable, and the absence of lateral intercommunication between the milk-ducts makes vertical incisions such as have been recommended for Hevea almost useless, as a single cut may only tap the contents of a single duct, and that ineffectually. Ineffectually, for as Dr. C. O. Weber points out (Castilloa in Colombia—*I. R. & G. P. Trades Journal*, Sep. 29, 1902) the latex is held in the vertical ducts by capillary force, and longitudinal incision of a vessel operates to relieve the pressure exerted on those ducts by the turgescence of the collateral tissues of the tree, thus diminishing the flow from the wound.

Horizontal cuts, on the other hand, though opening a number of ducts at one stroke, are not altogether satisfactory as regards collection of the rubber fluids, as they allow the latex to drip and coagulate either on the stem or on the ground, to the detriment in point of purity, of the resulting rubber. Several simple devices, however, will occur to the planter for the correction of this. The V-shaped cut, sometimes used in *Hevea* tapping, has been objected to by Central American Planters on the ground that the latex of a good *Castilloa* is so thick and creamy that it will not flow down the sloping channels, but coagulates on the edges, blocking further exudation from the mouths of the vessels. But this objection does not apply in the East Indies, where Castilloa latex has, as a rule, been found quite fluid enough to be easily manageable.

M. Cibot, the Bolivian Planter and explorer, whose share in the discussion as to the possible exhaustion of the Amazon rubber supply has already been noticed, says that in his observations upon cultivated *Castilloa* in Venezuela, he has tried a variety of tapping knives and scoring tools, including one the description of which

tallies with that of Mr. Holloway of Ceylon (*Journal d'Agriculture Tropicale*, No. 27, 1903), but found all unsatisfactory, from their tendency to drag the edges of the vessels instead of making a clean cut, thus closing them and sealing up the flow of latex till re-started by fresh scraping and cutting. He frankly pronounces in favour of the Indian *machete* or cutlass—presumably however he means it to be used with the discretion a careful planter would exercise in the interests of his own trees, not in the spirit of Mr. Rowland Cator's Nicaraguan guide, who objected to the trouble of filling the *machete* wounds on each tree with clay before passing on to the next. "We find ten—twenty mo' trees," said this worthy, "while 'um doin' that. What good? Perhaps I never come here no more!"

In electing to revert to the machete, however, M. Cibot's attention may not have been drawn to the chisel-and-mallet arrangement invented by Dr. Parkin for use in Ceylon on this tree—a kind of cold chisel 25 to 35 millimetres in length and 5 or 6 mm. thick at 3 mm. from the cutting edge, to be driven by means of the mallet into the bark to the required depth. This might probably have given him better results, and is certainly deserving of trial in India, whether the V-shaped cut or the half-spiral system (already described for *Hevea*) be adopted.

One or other of these systems will most likely be found suitable according to circumstances, but as *Castilloa* planting, even in Central America, is still in its infancy, the point is one for further experiment. Long before any planter now commencing operations can arrive at the tapping stage, a stock of matured and trustworthy opinion will have been recorded, by which he may be guided if by then he has not settled the question to his own satisfaction.

The same remarks apply to the point of when to tap and how much to extract with safety. Central American

planters, having regard to the creaminess of the latex from their trees, prefer to tap in the rains when it is more fluid, selecting the intervals between showers. But we have seen that this difficulty does not beset the planter in the east, who need not incur the risk of having his latex washed away by a sudden shower during the process of collection. He will prefer the dry season for his harvesting. The quantity he may expect to get per tree is also a matter of local experience. The dry rubber in the latex averages 25 %. But estimates of actual yield range from 8 oz. per tree per annum to 50 lbs., both extremes being established fact. For India it is probably undesirable to attempt serious tapping much before the eighth or ninth year. The tree is much more sensitive to injury than is the *Hevea*, so it is commonly stated (our own experience does not bear this out), and a writer in the *Ceylon Tropicale Agriculturist* quoted by Sir Geo. Watt in his Dictionary Article on this rubber goes the length of saying that as, by tapping, the trees are in any case killed in five or six years, felling is preferable, as practised in Panama, for by cutting down the tree you get the same amount of rubber at one collection as would be obtained by keeping it alive and tapping it for that period. The reader may not require the fallacy of this doctrine to be pointed out in so many words, but as the assumption that the tree is necessarily killed in a certain number of years by tapping may be found, or its existence inferred, in so much that has been written on the subject, it may be as well to examine the case. As a practical planter in Costa Rica, M. Koschny's views making the necessary reservation, deserve attention. He says (*Journal d'Agricultural Tropicale*, No. 6, December 1901) :—

"I reckon that at the rate of three tappings a year, one cannot without danger draw more than 1 lb. of rubber from a tree in its eighth year, and that only from the most vigorous. As for weaker ones, as much as one pound should not be taken. I consider that progression ought to be very slow, and that it would be imprudent to increase the tribute of one's trees by more than ½ lb. of rubber

every two years . . . I should be inclined to give cultivated *Castilloas*, as a general rule, a year's rest in every three . . . My system admits of a certain latitude——you may adapt it to circumstances. Thus you will try to make the period of rest coincide with the fall in the price of rubber, content to recoup yourself by more energetic tappings when the normal prices have become current."

The reservation to be made is that the question is not one of exhaustion of the rubber-fluids of the tree to its detriment—a matter to which the tree is, as a rule, quite indifferent, but the degree of injury to the heart-wood directly or indirectly by the openings given to xylophages and atmospheric influences prejudicial to the life of the tree. The current expression "bleeding to death" is a question—begging one, to which this theory seems often due. There is no real analogy between the laticiferous system of the rubber-plant and the circulatory system of the animal. What is indicated by way of treatment is some artificial protection, applied immediately after tapping is over, to replace the normal covering of the stem until nature can effect the necessary repairs. Wright (*Pará-Rubber*, 2nd Edn., 1906) suggests some waterproof fabric which, while affording protection from rain or sun, will not harbour insects. This he would arrange loosely as a mantle, or wind round the stem after the fashion of a *puttie*. This may answer in certain cases, but I am inclined to prefer as a protective material Woodrow's grafting-wax (*Gardening in India*, 3rd Edition, 1889, p. 71). His formula is: equal parts by weight of resin, bees-wax, lard, and turpentine, melted together over a slow fire. When required for use, heat in a water-bath or glue-pot, and brush over the surface to be protected while warm enough to take the required form but not so hot as to injure the tree (the test being whether the hand can bear the temperature of it).

Several methods of coagulation have been tried with success. J. H. Hart, Superintendent, *Trinidad Botanic Gardens*, points out (*India-rubber World*, October 1900)

that in all probability the bursting of the globules, vessels, or particles of rubber, or rupture of the surface of the particles, must take place before they can form a rubber mass, and the simpler the means by which this can be effected the better, probably, will be the quality of the product. Dr. Preuss (*Expedition nach Central-und-Sud Amerika*, Berlin, 1901) describes a primitive but very efficient method, the principle of which, with improvements, has been embodied in the "Beta Rubber Separator" (patented by Thos. Christy, 25, Lime Street, London, 1889). His note is as follows:—

In a plantation in Guatemala, at Aguna, I have come to know of an excellent method of preparing *Castilloa* rubber:—"The latex is poured into a tub fitted with a cock close to the bottom; it is vigorously stirred with a large quantity or water which is then left to settle, the latex floating on the surface; the water is next run off and replaced with fresh: aftor three successive washings the rubber is left to coagulate spontaneously, without the addition of any chemical ingredient, ending up with submitting it to pressure in a little press. The caoutchouc thus obtained is pure, dry, not sticky; it has a clear greyish-yellow colour which does not change for some months. By this process is obtained the best *Castilloa* rubber I have ever seen; it is even superior to that which Mr. Hart prepares at the Botanic Garden, Trinidad, by means of the Biffen Centrifugal Machine."

7.—ESTIMATES OF OUTLAY.

Almost all the estimates available to show cost of planting with *Castilloa* alone (but allowing for catch crops so as to get earlier returns) are Central American, stated in dollars. The following (*India-rubber World*, December 1889) may be taken as a fair sample, the dollar (gold) being reckoned roughly at Rs. 3:—

"Estimate for a plantation of 80 acres, containing 9,600 rubber trees, 12,000 cacao trees, and 12,000 hills of bananas. Labour $6 to $8 gold, per month. It is estimated that the rubber trees will give 2 lbs. of rubber a year each for thirty years (commencing from the ninth year) and the cacao 8 lbs. annually for the same length of time.

ESTIMATE.

First Year.	$	$
Cutting down forest and planting 12,000 hills bananas @ $\frac{1}{2}$ per acre	640	
Cleaning and cutting down weeds once @ $2·75 acre	220	
Gathering and planting 10,000 rubber seeds ..	20	
Gathering and planting 13,000 cacao seeds ..	50	
Care of rubber and cacao nursery	37	
Replacing banana plants which may die ..	50	
Manager's salary	600	
Four pack horses and equipment	200	
Plantation house	500	
Labourers' House	100	
Commissary and Storehouse	200	
Furniture, $25; Safe $100	125	
Stationery	15	
Farm implements	200	2,957
Second Year.		
Two cleanings of plantation @ $2·75 per acre ..	440	
Transplanting 9,600 rubber-trees	120	
Transplanting 12,000 cacao trees	160	
Gathering and planting seed for transplanting ..	10	
Care of nursery	12	
Marketing 15,000 bunches bananas @ $2\frac{1}{2}$ cents ..	375	
Manager's salary	600	
Stationery	15	
Boats	100	1,832
Third Year.		
Two cleanings of plantation @ $2·75 per acre ..	440	
Replanting rubber and cacao	80	
Hoeing and care of plants	200	
Planting and care of nursery	10	
Marketing 20,000 bunches bananas	500	
Manager's salary $600; Stationery $15.. ..	615	1,845
Fourth Year.		
Two cleanings of plantation	440	
Replanting rubber and cacao	60	
Hoeing and pruning	300	
Planting nursery	5	
Marketing 20,000 bunches bananas	500	
Manager's salary $600; Stationery $15.. ..	615	1,920

Fifth Year.	$	$
Details similar to 3rd year, with these additions ..	1,845	
Marketing 10,000 lbs. cacao @ 4 cents per lb. ..	400	
Drying house and appliances	160	2,405
Sixth to Eighth Years.		
Similar to 5th year, with increases for marketing..	2,575	
Do. 6th do. do. do. ..	2,805	
Do. 7th do. do. do. ..	3,425	8,805
Ninth Year.		
Similar to foregoing, with addition	3,615	
Marketing 15,000 lbs. rubber @ 5 cents ..	750	4,365
Tenth Year.		
Similar to foregoing	4,475	4,475
		28,604
Income for Ten Years.		
Cash crops (cacao and bananas)	58,760	
Rubber (two years)	20,520	79,280
Surplus proceeds for Ten Years ..		$50,675

ATE XI.—Ceará rubber-tree (Manihot glaziovii).

CHAPTER IV.

MANIHOT GLAZIOVII.

1.—DESCRIPTION OF THE PLANT.

The Ceará Rubber-tree or Maniçoba, like the *Hevea brasiliensis*, is one of the Euphorbiaceae. It is a moderate-sized tree resembling a birch in outward appearance, about 20 inches in trunk-diameter when full grown, and may run to 50 ft. in height. In one of its types its branches form a spreading leafy crown, taking the shape of an inverted basket; in another they point upwards with a very slight declension from the vertical, or curve outwards and straighten themselves again candelabra fashion, putting forth comparatively little foliage. The bark varies in colour, the tinge most frequently met with in the east being a purplish-grey, showing a pale-green cambium where the outer layer has peeled off, which it does in horizontal strips of ¼ inch to 1 inch in breadth. Brazilian writers note another kind, with bark of a chocolate colour, stripping similarly, but in much broader strips. The stem is usually straight, branching at 10 or 15 ft. from the ground. The roots are spreading, tuberous when young, the tubers being edible and not unlike those of the cognate manioc, but more spongy and filled with latex for the first few years of their growth. Later on these tubers elongate around the roots, ceasing to stand out distinct from them. The tree is deciduous in the dry season. The flowers are large, male and female separate on the same raceme. The fruit is formed somewhat like that of the *Hevea*, with three lobes, each containing a hard shining seed, drab-coloured and speckled with black, but much smaller and more oval, being about the size of a French bean.

2.—NATURAL CONDITIONS, HABITS, ETC.

The plant is a very hardy one. Cross, the naturalist to whom its introduction into India is due, describes the region of its origin as one of the most arid in Brazil. The climate is tropical, as in the case of the Amazon valley, but there the resemblance ends. Its rainy season only lasts from February to June, and is followed by a well-marked dry season lasting the rest of the year, often without a single shower intervening. Mean temperature 26° C. (79° Fahr.); mean of the maxima slightly over 35° C. (96° Fahr.), and of the minima but little below 26° C. Elevation not much above 200 ft. The soil in which Cross found the plants growing was for the most part soft sandstone or gravel and sand bound up into a kind of concrete, from which it was almost impossible to uproot the specimens required without destroying the tubers. Other places where it abounded were nearly as impracticable, for instance in crevices between boulders, each probably weighing 50 tons. The forest was fairly high, but devoid of all undergrowth, grass, ferns, or moss.

3.—LOCALITY FOR PLANTING.

It is said, to take an extreme case, that the wet of Singapore, where this plant was tried, killed it off. This is probably true. But a considerable amount of moisture evidently does it no harm, for all through the Pará rubber plantation at Mergui in Tenasserim, where the rainfall is heavy though not incessant throughout the year, many very healthy specimens of Ceará rubber are to be found, standing out conspicuous among the *Heveas* by their characteristic bluish-green foliage. Cross, having regard to the conditions of the plant in its Brazilian home, advised the Ceylon planters to put it down on land possessing just sufficient soil to support stunted trees and scrub, on exhausted coffee lands, or on gravelly wastes. This advice was not incorrect, but it represents the opposite extreme to the case of Singapore. Planters were not long in finding out that the tree did not actually prefer the very

poorest soils, and that as a matter of fact it did remarkably well anywhere between the two extremes, and had no objection to a liberal share of moisture. It is certain that the minimum of 60° Fahr. may also be passed without serious detriment to its growth, whatever influence on its yield a greater degree of cold may have.

4.—REPRODUCTION.

This is a matter of no difficulty whatever, the tree growing as freely from cuttings as from seed. The seeds, however, being very hard in the shell, the latter should be filed at the radicular end, care being taken not to injure the radicle itself. If this be done, it will be enabled to split up in the ground, and the young plant to appear within a few weeks instead of twelve months—the normal period of germination. But as the greatest possible variation is to be found between plants of the same sowing as regards yield, special care has to be taken in the selection of the parent tree. In this connexion, the letter addressed by M. A. Cardozo, a planter of Moçambique to the *Journal d'Agriculture Tropicale* (No. 33, March 1904), deserves quotation :—

"This is what I have observed in my plantation, and also on the few older trees to be found at Inhambane. If the trees grow under favourable conditions, they will have produced branches and acquired their final form between the first and second year. These forms, although somewhat variable, fall readily into two principal types." (The writer here gives two illustrations, the first a section or skeleton of a tree branching candelabra fashion, the second branching much on the pattern of the common Indian grass fan). "In the first type are the trees presenting a trunk straight throughout and vertical, like the branches of a very narrow V, and running up to the height of 6 metres or more. The other type is that of a tree with its trunk straight or curved, rarely exceeding two metres in height, whose branches diverge widely from the vertical, sub-divide freely, and put forth a very leafy foliage, the tree reminding one of a big orange-tree. In the former type the foliage is much less abundant.

"The latex of the trees of the former type is always very thick, and contains plenty of rubber; one can tell at a glance that it is

a good yielder. In the second type there are good and bad, but I have not yet been able to tell which is which at sight. A single incision, however, even before the second year, will settle this question definitely, as at that age the latex is already very liquid in the bad, and fairly thick in the good *Manihot*. The bad yielders should be uprooted in their second year, for some of them begin even then to seed, and this seed must be prevented from falling on the ground, where it would, if allowed, infallibly propagate the bad type."

M. Cardozo has not yet (July 1906) announced the results of his experiments in selection, but the matter has been taken up elsewhere. In the Annual Administration Report of the Government Botanic Gardens on the Nilgiris for 1901-02, the following passages occur :—

"To collect and plant in order in Burliar or elsewhere the progeny of the best rubber-yielding trees which are discovered in other plantations from time to time, with a view to comparing their relative merits, nine pits, 26½ ft. apart in one line, parallel to, and 30 ft. distant from, the last line of *Castilloa*, were planted with cuttings on the 9th February, 1902, and with seeds on the 6th March, 1902, taken from the best rubber-yielding tree yet found at Bekki Kolley, Wynaad. It may be mentioned that this particular tree, which girthed 3 ft. 3 inches at 2½ ft. from the ground, yielded 14 ounces of dry rubber after one tapping, which was made on the 30th January, 1902, adjacent to the line planted with the Bekki Kolley variety is a line of eight pits, 26½ ft. apart, planted on the 23rd February, 1902, with both seeds and cuttings of the Kullar variety. The yield of rubber from the parent tree (now dead) was never accurately determined, but it was known to be good.

"Mr. H. G. Parsons, of Beechlands, Pollibetta, South Coorg, in his letter, dated 25th January, 1902, to the Curator, states that he possesses a Ceará rubber-tree 20 years old that is yielding 10 lbs. of rubber per annum, and he further states, 'I have no other tree that in any way comes near such a yield, and some give next to no latex.' Mr. Parsons has quite recently sent here a few seeds from his best tree and has also promised to send a few cuttings of it. The seeds have been sown, and should they germinate it is intended to plant a third line at Burliar with the seedlings. Should this variety prove in due course a better rubber-yielder than the Bekki Kolley and Kullar varieties, a distinct advance will have been made in the work of selection which has been undertaken."

"On the cleared area which is free of mahoganies, the following species of rubber-yielding plants have been planted, 30 ft. by 30 ft. :—

First Line.—Eight pits planted in February, 1902, with the Bekki Kolley variety of the Ceará rubber-tree;

Second Line.—Eight pits planted in February, 1902, with the Kullar variety of the Ceará rubber-tree;

Third Line.—Pits vacant—to be planted with Beechlands variety *vide supra.*"

It will be interesting to know whether these experiments confirm, in whole or in part, the theory of M. Cardozo regarding the comparative values of the candelabra and the weeping or fan-like type of *Manihot glaziovii:* also whether they afford any criterion for the recognition by external aspect of the good and the bad Ceará contained in the latter ambiguous class.

5.—LAYING-OUT THE PLANTATION.

If it is intended to form a plantation, or sections of a plantation, exclusively of Ceará rubber, the general plan, intervals, etc., need not be widely different from those suggested for *Hevea.* But as the tree is quite able to hold its own once it gets its chance, the trouble and expense of digging pits and piling up mounds for it need not be taken. Considering how freely and how early it seeds, it should be sufficient to plant it at wide intervals, say 50 ft. apart, and allow it to fill the plantation by spontaneous reproduction, thinning out the stunted or over-crowded plants later on. But, *vide* our suggestions for a mixed plantation in the 9th chapter of these notes, the intending planter may find it worthwhile to consider whether this tree cannot be turned to better account by utilising it as a subsidiary plant to mark out blocks and preserve a kind of sanitary cordon round each in the event of disease appearing in a neighbouring section, rather than by making it the staple crop of his estate.

6.—HARVESTING.

This is the crux of the matter, where this tree is concerned, though indeed the same holds good of all. The

cultivation of Ceará rubber has from the first proved a grand success in all respects but one—it has never as yet been made to pay. The planting community of Ceylon took it up very keenly in the seventies and eighties, and devoted much attention to it till drawn away but the superior claims of tea, and, later on, of Pará rubber. According to the *Journal d'Agriculture Tropicale* (No. 35, May 1904), Ceylon exported in 1892, 7,280 lbs. of Ceará rubber, and in 1896 as much as 17,591 lbs. But the following year the output fell to 2,792 lbs. and since then it has not been reported separately, being merged in the new product, Plantation Pará. In all probability no increase has taken place, as the acreage under Ceará in 1904 was only 500 acres, or exactly half that of 1883.

But in Bangalore (*Tropical Agriculturist*, October 1893, p. 247, and *Mysore Government Gazette*, April 1904) a series of experiments have been made by Mr. J. Cameron, the Director of the Botanic Gardens, the result of which goes to show that trees of from eight to fourteen years of age may be very rich in latex, and, provided the tapping is done at the right season and in the right manner, may yield very fair quantities of rubber. During the dry season, it is recommended that tapping be confined to the roots; after the rains, and throughout the cold weather, it will be the turn of the trunk. But in whatever way the tree is tapped, the variations in yield, between trees grown in exactly the same conditions and of the same age are large and inexplicable. Mr. Parsons' tree at Beechlands is a case in point; and many such cases are noted at Bangalore. One tree, of fifteen or sixteen years, bled 83 times in a single year, produced seven pounds of caoutchouc. Another, treated similarly, yielded three pounds, while a third (five years of age) gave little or no rubber, its latex being very watery. According to M. Cardozo, a tree of five years of age whose latex is watery should be cut down as hopeless, the quality of its yield being by then as fixed as it is ever likely to be.

Among the more important conclusions drawn by Mr. Cameron from his experiments are these :—

At fifteen years of age all the woody parts of the tree itself, including the roots, are gorged with latex. Even when the roots are exhausted by tapping, there is latex in the stem, and *vice versâ*. The best time during the day for tapping is from 6 to 8 A.M. Tapping should not be done in the rains, but may be done at short intervals throughout the rest of the year. Special implements, and gentle methods, should be used. It is best merely to strip the outer bark and to polish the inner with sand-paper before cutting or pricking it, so as to have a smooth surface for the latex to trickle over.

Our own experiments, conducted in Rangoon in 1897-98, had for their object the testing of the cost of extraction. We cannot claim that they are conclusive except perhaps as regards Burma, where the rate of wages is more than double that of this part of India. Being conducted moreover on a small scale, it was not easy to make the correct allowance for cost of supervision. However the tests were extended over a considerable period, and were averaged, the final result being to show that Ceará rubber in Burma cost Rs. 3-2-0 per lb. to produce. The market rate of the article being then about 1/6*d*., it was obvious that some improvement in the methods employed and a substantial reduction in the rates of pay given the coolies would have to be effected before the planting of this kind of rubber could be commended to the cultivator.

The July number of the *Journal d'Agriculture Tropicale* for this year, just to hand, contains a contribution by M. Berthelot du Chesnay, a planter of the French Congo, who seems to have arrived at much the same conclusion. He says that the Niewe Afrikansche Handels Venootshaap, a Dutch Company planting at Cayo

on the river Soeni, possess 2,000 full-grown Cearás, and the results of their tapping may be summarised as follows :—

The yield of the 2,000 plants was 95 kilos. of dry rubber, or an average of 47 grammes per tree, the time taken by 35 workmen to get this in being five weeks. As the labourers were paid at 40 centimes a day, the cost of collection was thus 5 fr. 24 per kilo. To this has to be added the cost of coagulation, handling and transport, as well as of cultivation, so as to get at the exact return per kilo., and it is easy to reckon that even cutting the figures of expenditure to their lowest, the sum total will be far higher than the selling price of the stuff in Europe.

Time of tapping, the beginning of the rains, the trees giving almost nothing in the dry season. At the end of the tapping it was noted that most of the trees had been killed, either directly by the wounds inflicted, or by the termites attacking the wounded trees.

PLATE XII (*a*).—Avenue of Ficus elastica at Peradeniya, Ceylon.

(*b*).—Ficus elastica at Peradeniya, Ceylon (Assam rubber).

CHAPTER V.

FICUS ELASTICA.

1.—DESCRIPTION OF THE PLANT.

THIS tree, dwarfed into a conservatory or drawing pot plant, is a well-known one in Europe, and has even been grown in the open air, a fine full-grown specimen existing a few years ago (and possibly to this day) in the Parc Monceau, Paris. In its natural state it resembles the banyan, and like it belongs to the Natural Order Urticaceæ. Of the forests of the East-Indian Archipelago it is one of the most striking features, growing as it does to 180 ft. in height with a huge circumference. It is generally epiphytic in habit, rooting itself in the forks of the upper branches of some other forest tree, which in the course of time it strangles with its aerial roots as these form stems. The ends of the branches of this tree are armed with scales curled up in the shape of horns, generally of a bright red, but sometimes white. When these scales fall, they leave a circular scar. On the young plants and on the suckers the leaves are very large, sometimes exceeding a foot in length, but in mature trees they are generally about half as long, retaining however their characteristic shape and system of nervation. They are alternate, oblong-elliptic, leathery in texture, dark-green with a peculiar glossiness. The base is rounded or contracted, the extremity an obtuse point. The secondary ribs or veins of the leaf are its most notable feature, being parallel, numerous, and very close to one another. They rise from the midriff almost at right angles to it, but are not very prominent, and at the edges of the leaf they unite into a corded hem as it were, running all round the leaf. At the base three or four larger veins branch out from the petiole and leaf-

base, and run obliquely through the leaf to either margin. The leaf-stalks are from one to two and a-half inches long. The bark of the stem is smooth, light-grey to brown in colour, and the wood white, soft, perishable. The fruits are about the size of a pea or small bean, conical, growing in pairs in the axils of the leaves. When ripe they are of a greenish-yellow colour. The capsules conseeds like those of the fig tribe generally, but extremely small.

2.—NATURAL CONDITIONS, HABITS, ETC.

The Ficus elastica is found in the natural state widely distributed over the tropics and beyond them to the north, Assam and the upper rainy zone of Burma, well into the Chinese Province of Yunnan, being the regions where it is most abundant. It is not gregarious, though occasionally small groups of it may be found in the mixed forests. As a rule it stands out singly, its size and dark-green glossy foliage marking it out conspicuoulsy from its neighbours. Like many of the fig tribe, its dissemination is due to the birds of the air which feed on its fruit and void droppings containing the undigested seeds on the higher branches of the tree on which they perch. In their passage through the alimentry canal of the bird the seeds get an important impulse towards germination, but the subsequent progress of the young plant during the epiphytic stage is very slow. The aerial roots remain as slender as whipcords till they reach the ground—a process taking many years to complete. Once in contact with the soil, however, the cord becomes a stem, and in due course the vicinity of the central tree forms a leafy vault supported by innumerable columns. From the mode of its reproduction it is hard to infer what kind of soil best suits it, but in cultivation it is found to thrive on moist but well-drained lands such as are appropriate to *Castilloa*. Climate seems to be a most important factor in success from the commercial point of view, it being one thing to raise the plant, and quite another to turn it to profitable account as a rubber-tree.

3.—LOCALITY FOR PLANTING.

There is no reason why this tree should not be grown alongside of Hevea and Castilloa. In practice it has been found to flourish wherever these species are under cultivation. At Mergui in Southern Burma it is to be found strong and healthy in wide clearings made in virgin forest, with but little lateral and no overhead shade. Elsewhere in Burma it has been grown on open hillsides, and in ravines where in the rains torrents of water flow. In Belgaum it has been put to a severer test, having been planted and come to maturity in an enclosure exposed to the radiation of masonry on all four sides, on a soil devoid of other vegetation; and what is more remarkable and important, has yielded a very fair quantity of coagulable latex (from which samples of rubber have been made and exhibited, both at the Bombay Exhibition of 1904 and that of Peradeniya in 1906).

I do not however think this method of planting is one to be copied, nor indeed am I convinced that the tree is worth cultivation in this part of India for its own sake. Suggestions for its use in combination with more valuable rubbers, as a wind-belt and a fire-protector as well as a subsidiary source of rubber, will be found in the closing summary of results, at the end of these notes.

4.—REPRODUCTION.

Natural methods are not to be imitated unless the planter is content to work for posterity alone. Propagation from cuttings is said to be easy, but such is not my personal experience. The following is the system employed in the Assam plantations (*Handbook of Commercial Products*, Imperial Institute Series, No. 25, Calcutta, 1893):—

"The seed ripens from January to March, when it is collected as it falls from the trees, and afterwards dried in the sun. It is, properly speaking, the fruit, and consists of small figs, the size of a pea. These at the time of sowing are broken between the hands, and the seed thus mixed with the particles of the fruit is sown without any attempt to clean or separate the seed. Germination

takes place sometimes only three months after the seed has been sown, and as it is very small, it must be sown on the *surface* of the soil alone, but otherwise just like the seed of any other plant. It requires as much light as possible from above; side shade is an advantage. The seed can be sown on beds, or in boxes or flower-pots, but it is most essential that the drainage of the soil be perfect, and that the earth never becomes soaking wet, whilst, on the other hand, it should never be allowed to become thoroughly dry, but always be kept moist."

"As the seedlings are very small at first, they must be treated with great care, and drip from trees above the seed-bed must be guarded against; the soil must be kept loose, and open vegetable mould is the best soil. When the seedlings are 2—3 inches high, they have already formed a little thickened root something like a small carrot, and can then be transplanted very safely; this should be done on to a properly dug nursery bed, well drained, and the seedlings should there be placed in lines, also a foot from each other."

"After the seedlings have become 1—2 feet in height they are very hardy, and can be transplanted at any time of the year, but as the deer are very much after the leaves of the rubber-trees, and to avoid the great expense of fencing-in our plantation, we have of late years transplanted the young trees a second time in nurseries giving them more room, say 3—4 feet square each plant, and let them grow until 10 to 12 feet high, when they can be put out in the plantation without fear that the deer will destroy them; they require, however, a strong stake each, as the deer will bend the young trees down with their horns if not staked."

The same authority goes on to say:—

"These rubber-trees can also be propagated readily from cuttings, if only perfectly ripe young branches or shoots be used; but young trees so raised are never so hardy as the seedlings, and do not make such good growth afterwards."

Local experience in this matter, in Belgaum at least, points to rather the opposite conclusion. The cuttings that persistently failed were those taken from ripe branches, with a fair formation of wood in them; whereas those that succeeded (and they were by no means too numerous—barely five per cent. of the cuttings taken) were slips not over a foot or a foot and a-half in length, taken from the ends of the youngest branches, with the leafy

horn still on them. This was the more remarkable, inasmuch as my notes of the Mergui plantation, where the Assam method had been followed, recorded excellent results

Another mode of propagation, more elaborate but perhaps more expeditious in the end, is that employed in the Nilambur (Malabar) plantations. It is as follows:—

"A seed bed, 10 feet long by 2½ feet broad, should be prepared. The soil should be first well forked over to a depth of at least 18 inches, well pulverised and mixed with sifted stable manure, old ashes and sand. The proportion of mould, ashes, and manure should be as follows:—one of mould, two of sand, one of ashes, one of manure." All these materials should be sifted through a wire-gauze sieve. The bed should be raised 4 inches above the ground, and the surface made perfectly level and smooth. On the top of this layer one inch thickness of stable manure and river sand, in equal proportions, should be sifted, and over that a layer of brick or tile dust ¼ inch thick also sifted. The dried fruit should now be rubbed to powder between the hands, and then sifted and sown thickly over the brick dust. After sowing the seed, a flat smooth piece of board would be gently pressed all over the bed, the surface of which should in this manner be made as level and smooth as that of a billiard table.

"The bed having been prepared and seed sown, it should be watered. A small garden engine should be stationed close to the bed and a very fine spray allowed to fall gently over the bed till it is well moistened. This can be done by placing the thumb of the left hand over the muzzle of the delivery pipe of the engine. It is essential that none of the seed, which all lies on the surface, should be washed away. A sheet of galvanised iron, or any efficient substitute should now be placed about 6 inches above the bed, so that no rain water may fall upon or injure the surface of the bed which must always be kept damp, and in dry weather three or four waterings a day may be necessary."

"In about ten days the young seed should germinate freely, and it will be necessary to admit sunlight from 3 to 6 hours daily. In cloudy weather the young plants may be exposed freely all day, and a very light drizzle will not hurt them, but if the upper surface of the bed is once allowed to dry, or is broken up by heavy rain, the young plants will perish. The gardener in charge, who should be a trustworthy man, should be directed to remove the covering of the bed morning and evening, and give the young plants a free allowance of sunshine daily.

"Several nursery beds should now be prepared. They should be heavily manured, and 4 inches of the surface made of sifted soil. As in the case of the seed-bed, a ⅛ inch sifted brick or tile dust will be found necessary. Into these nursery beds delicate young seedlings should be carefully pricked out 1 foot apart, with a porcupine quill or a strip of bamboo, when ½ inch in height. In these nursery beds the young plants should remain till 3 feet high, and then be planted out permanently from 40 to 60 feet apart in pits 3 feet by 3 feet."

These are certainly elaborate methods, and may not be considered worth the practical planter's while to adopt. I should be inclined to suggest a partial imitation of nature's method; feed the estate poultry upon the fresh or partially dried figs, and keep them cooped up till all the excrement likely to contain seed has been collected. Then sow the collections in seed-beds, and proceed further as the case may indicate.

5.—LAYING OUT THE PLANTATION.

The Nilambur plantation authorities recommend planting in pits, and this was the mode adopted in the Mergui plantation, with apparently satisfactory results. The Assam system of planting on mounds 3 or 4 feet high may be more laborious and consequently more expensive, and the method described in the present notes as that used in the case of Hevea (pits dug and filled in loosely so as to form mounds with earth and manure added) may be even more so, but there can be no doubt as to the superiority of both in the long run.

Should a plantation, or a section of a plantation, exclusively composed of *Ficus elastica*, be contemplated, the following instructions taken from Mr. G. Mann's "How Rubber-trees are grown in Assam" (*Kew Bulletin*, April 1891) will be useful:—

"To ensure the greatest possible amount of moisture in the atmosphere, the plantations of *Ficus elastica* in Assam have been made in the moist evergreen forests near the foot of the hills, through which lines 40 feet in width have been cleared 100 feet apart from centre to centre of the lines, thus leaving 60 feet of

PLATE XIII (*a*).—FICUS ELASTICA 18 MONTHS OLD RAISED AT BELGAUM FROM CUTTINGS OF GREEN WOOD.

(*b*).—FICUS ELASTICA AT BELGAUM RAISED FROM A CUTTING AND PLANTED IN AN UNFAVOURABLE SITE.

forest standing between the lines. On these cleared lines the mounds for the planting of the seedlings or saplings are thrown up a distance of 25 feet apart. Care has to be taken afterwards to prevent the forest trees left standing from closing in above over the lines and the rubber-trees planted on them, which they have always a tendency to do, and which, if not guarded against, is very detrimental to the growth of the young rubber-trees. This is easily effected by lopping the branches of the forest trees left standing. The undergrowth which springs up on these lines, and, as a rule, grows most vigorously, has also to be cleared two or three times in the year for the first four or five years, to admit air for the young rubber-trees; but beyond this, and the putting occasionally more earth on to the mounds on which the trees were planted nothing is necessary.

"The lines for the planting are cut in an east and west direction, so as to protect the young rubber-trees against the strong sun in the middle of the day; the atmosphere also keeps moister than if the lines were cut north and south. High ground is always best, and swampy ground, where water lodges, should be avoided; but the tree grows very well on alluvial flats on the banks of rivers even though the land be inundated for a few days once or twice in the year."

These remarks are of wider application; *mutatis mutandis* they bear on the case of whatever tree may be selected as the staple rubber for the plantation.

6.—HARVESTING.

Much of the available information regarding yield of the *Ficus elastica* goes to show "how not to do it" rather than the reverse. Take for example the following notes by Mr. O'Bryen, who was a Conservator of Forests in Upper Burma about 1892, upon Kachin methods in the Mogaung sub-division of Bhamo district:—

"The quantity of rubber obtainable will depend on the size of the tree, and also on the number of times it has previously been tapped. A large tree with three or four stems and a well-developed crown will yield the first year it is tapped 60 to 70 viss (210 to 245 lb.); if tapped again the next year (the Kachins invariably tap a new tree three years successively), its yield will fall off to 40 viss (140 lb.); and the third year not more than 15 to 20 viss (or 52 to 70 lb.) are obtainable; the fourth year it would yield nothing. If after

having been tapped for three years successively it be allowed to rest for a couple of years, perhaps 25 viss may be obtained; but by the three successive tappings the vitality of the tree is permanently injured. This impaired vitality is shown by a falling-off in the size of the leaves, which instead of a length of 5 or 6 inches, are only a couple of inches long; by the paucity of leaves in the crown; by the dying of the uppermost branches, and by the inability of the tree to recover the places where the incisions were made. The latter sign is specially noticeable where the roots have been tapped, as the wood is deeply cut into. The wood of *Ficus elastica* is white and extremely soft, and liable to decomposition; consequently if the wounds are not quickly covered over, rot sets in, and progresses with astonishing rapidity up and down the stem, and in a very short time the tree is smashed off in a gale of wind."

The lesson to be learnt from these facts is one of equal importance be it *Hevea*, *Castilloa*, or other rubber that is in question. It is not the drain of latex itself that kills the tree, but the exposure of the heart-wood to the action of wet, fungus, and xylophages—a matter that has been fully discussed in the corresponding section of these notes, heading *Castilloa elastica*.

Another observation of the same writer deserves quotation. He remarks:—

"The quantity of rubber produced by two equal-sized trees, one on the hills and one in the plains, is not to be compared. The flow of juice from the tree in the plains is abundant in quantity but produces very little rubber on hardening. The tree grown on the hills has very little water in the juice that runs out. The Kachins have long ago recognised this fact. Generally speaking, it is safe to say that the quantity of rubber yielded by the tracts which are easily got at is falling off considerably, and will continue to do so, unless severe measures are taken to preserve the trees."

The measures recommended by Mr. O'Bryen to deal with the abuses reported by him were:—

"That no person shall tap the main stem or aerial roots of the rubber-tree when they have a less girth than 3 feet at 3 feet from the ground. . . The aerial roots of *Ficus elastica* attain the girth mentioned in six or seven years."

Accordingly, in August 1892, the Government of Burma passed the following rule for the tapping of rubber-trees in the Bhamo and Upper Chindwin Districts :—

"Trees may be tapped only during the months of December, January, February and March. Stems or aerial roots measuring less than 3 feet in girth at 3 feet from the ground, as well as the underground roots of trees and the lowest part of the stem, within 3 feet of the ground, may not be tapped, and no india-rubber may be felled or burnt. The incisions must not exceed 1 foot in length and 4 inches in breadth."

Private planters would do well to observe these rules strictly in their own interests. The method I have generally adopted in practice, though admittedly a much smaller quantity of rubber is extracted thereby, is simply to bruise the stem of the tree or the branches or aerial roots with a big round stone or a wooden mallet. The single drawback to this method is that it does not draw away the latex as clean as might be desired. Chips of bark are apt to get mixed up with it, and can only be got rid of, working on a small scale that is to say, by a somewhat laborious process of manipulation during coagulation. If these impurities cannot be removed by this means before coagulation is complete, the only thing to be done is to cut the rubber into thin slices and wash it free from them. Hence it follows that the thinner the layers of latex put out in the pans for coagulation the simpler the process of cleaning them.

7.—ESTIMATES OF OUTLAY.

An interesting and indeed almost unique piece of information on the subject of *Ficus elastica* cultivation as a commercial undertaking was furnished by a Java Conservator of Forests about eight years ago in respect of a plantation, exclusively of this tree formed in that island. But as it deals only with returns, and makes no reference to cost of creating the plantation, its details have been reserved to the ninth chapter of these notes. The only available information on the latter point relates to the

experimental stage of operations in Assam, and is contained in a report to Government for 1884 (quoted by Sir George Watt in his Dictionary of Economic Products (IV, 1—63) :—

"The total area of the Charduar caoutchouc plantation is now 892 acres, and has cost Rs. 64,351 or Rs. 72 per acre; this is abnormally high, since much of the work during the first five years had to be done twice over, and sometimes oftener, because the planting of caoutchouc trees was new, and everything had to be learned and found out by experiments, which naturally took some time. But matters have changed in this respect; we know now what we are about, and the officer in charge of this work, Mr. T. J. Campbell, has estimated the cost of the extension which is at present being carried out at Rs. 29 per acre, to which another Rs. 6 for subsequent cultivation should be added, bring the cost, including everything, up to Rs. 35 per acre.

"Besides the experimental nature of the work, to which the cost of Rs. 72 per acre must to a great extent be attributed, we have also prepared extensive nurseries, covering an area of about 23 acres, and containing some 184,000 plants of different sizes, which is sufficient to extend the plantation by 200 acres per annum for the next 15 years, or a square mile per annum for the next five years, if desired; and these nurseries have been so planted that if for special reasons it is considered advisable not to extend the plantation at any particular time, the trees can be kept almost stationary for 15 to 20 years, without becoming less suited for transplanting, a particular advantage enjoyed by *Ficus elastica* in common with other semi-epiphytes, as compared with ordinary trees."

CHAPTER VI.

HANCORNIA SPECIOSA.

1.—DESCRIPTION, NATURAL CONDITIONS, ETC.

THE Mangabeira—natural order Apocynaceæ. This is a small, hardy, and somewhat slow-growing tree, seldom exceeding 10 or 12 feet in height, having its home on the sandy coasts of North-eastern Brazil, from Cape Roque southwards to S. Paulo, *i.e.*, a natural range of 20 degrees of latitude at least. It is not found at any great elevation, 500 feet being recorded as that most favourable to it. It grows in the open, apart from other trees and seems to prefer red soils, much after the fashion of the *Anacardium occidentale* (caju) of Portuguese India—a tree which, to a certain extent, resembles in habit, its branches drooping similarly. The crown of the tree is often of greater diameter than its height of stem, and the branches are more or less bare except towards the extremities, which bear most of the foliage. The bark of the stem and branches is brownish when young, and smooth. Later on it becomes corky. The leaves are opposite, 2 to 4 inches long, and 1¼ to 1¾ inches broad; elliptic or elliptic-oblong, acute at the base, and terminating in a point often obtuse. The petioles are very short. The nervation of the leaves is characteristic; the secondary nerves strike out from the midriff almost at a right angle, and are close together sometimes branching into two but always standing out distinctly up to the edge of the leaf. The flowers are about 2 inches long, grouped together in terminal panicles of seven. The fruit is about the size of a plum, yellow with red streaks when ripe, and of a delicious flavour. It is eaten both cooked and raw. Seeds few.

2.—LOCALITY SUITABLE FOR PLANTING.

This must, in the absence of recorded results, be more or less of the nature of an experiment, but as the tree has been highly recommended for trial on the laterite soils of

Western Africa, it is reasonable to suppose it will succeed in similar situations in India, at, or slightly above, sea-level. Portuguese India contains much land of the type apparently indicated, for example the lower hills and tablelands in the Province of Ilhas between Nova Goa and Dona Paula, or those in Bardez to the north of the Rio de Mapuça, terminating in the promontory of Agoada, and in fact wherever the *caju* is to be found growing spontaneously.

3.—REPRODUCTION.

This tree, possibly because of its slow growth and the low market value of its rubber due, it should be noted entirely to vicious modes of preparation, has not been tried in India at all, nor is there any mention of its experimental cultivation in the Straits Java or Tonkin. In S. Paulo, where the Government of the Brazilian Republic have encouraged its cultivation by offering bonuses to planters, it is said to be propagated mainly if not entirely from cuttings. It is reported, on the strength of actual experience there, to be very sensitive, when young, to water, many young plants having been killed by overwatering by hand, even on a sandy and permeable soil, though in its cultivated state, once this stage is passed, it readily accustoms itself to a moist climate, presumably much as does the *Manihot glaziovii*, a tree whose natural conditions are very similar. It has been reproduced at Kew, and is on sale in the nurseries of the seedsmen in Paris who make tropical products a speciality.

4.—LAYING-OUT THE PLANTATION.

This should be a very simple matter, as the tree is small and not exacting in its requirements as regards water or shade. Probably 10 feet by 10 feet would be ample elbow-room to give it. In Brazil it has been planted in combination with coffee.

5.—HARVESTING.

This should be deferred to the tenth year of growth of the *Hancornia*. The rubber it yields, known in the market as Mangabeira, and bulking nearly as largely in its

annual consumption as that of Burma and Assam together (*Ficus elastica* rubber), is of a beautiful rose colour, but as it has hitherto been coagulated by means of solutions of alum and sea-salt, it has seldom been produced in a dry state, and the loss in washing out the briny liquids thus imprisoned in its substance ranges from 40 to 60 %. The Strauss process, as it is called, is really a fraud upon the consumer of crude rubber in the guise of a scientific method of coagulation, and ought to be suppressed in the interests of all concerned. That it would pay to adopt any of the usual modes of rubber-coagulation found suitable to the case of Mangabeira is clear from the fact that in Brazil itself prepared *Hancornia* rubber has fetched 12 milrèis (fracos) per kilo, or very nearly the price of Fina Pará. The yield per tree has not, as far as can be ascertained, been placed on record as to result of actual observation by any European writer on the subject, but it is known that the average daily load of rubber brought in during the collecting season by each rubber-gatherer is over 12 lbs. Allowing 120 trees to the *estrada*—the usual reckoning for *Hevea* trees in the Amazon, this would indicate a daily yield of one-tenth of a pound of rubber, or about 3 lbs. per month. It does not appear on record how long the collecting season lasts, but taking it at three months, which is not by any means an over-estimate, it would seem reasonable to look for an average yield of 8 or 9 lbs. per tree per season. This is as much as a *Hevea* tree of the same age would yield, on the average, and should therefore repay the cultivator.

CHAPTER VII.

MINOR RUBBER-PLANTS.

1.—CHAVANNESIA (URCEOLA) ESCULENTA.

An apocynaceous scandent shrub. Branches and leaves quite glabrous. Leaves opposite, 4 to 6 inches by 2 to 2½ inches, acute at both ends or obtuse at the base; shining above; nerves red, slightly arched. Flowers minute, white; corymbs apparently short; long-peduncled glabrous in the axils of the upper leaves, or terminal. Follicles 5 by ½ inch, quite straight, pointed, narrowed into a stout stalk ½ inch long, thickly coriaceous when dry and hard. Seeds elliptic lanceolate, villous, ½ inch long, coma white, four times as long. The fruit is sharply acid to the taste, and is sold in Rangoon and Maulmein as a substitute for tamarind. The leaves are said to contain indigo in considerable quantities.

In Burma this creeper grows rapidly, covering trees 60 feet high in four or five years, but in Malabar (Nilambur plantation), where it has been tried, it is reported to be of slow growth. It is not beloved of the Forest Officer, as it is addicted to strangling valuable timber trees, and in the teak reserves of Burma it is one of a number of creepers for whose extirpation annual grants are given. It yields an excellent rubber, pale-pink in colour, resembling that of *Ficus elastica* when the latter is first formed, but not darkening to the same extent as it dries. It is far more resilient.

On the recommendation of the late Mr. Strettell, Burma Forest Department, an authority on Burma rubbers, a plantation of this species was formed at Kinpadi, in the Magayi Forest Reserve, midway between Rangoon and Prome. It was started in 1874, but in the eighties was

almost destroyed by a forest fire. On a visit of inspection paid by the present writer to it in 1896, the stock of creepers surviving or sprung up since the fire was about 1,000 plants. The most recent report of its working, as far as I know, are those in the Agricultural Ledger, 1903, No. 10, containing correspondence between the Director, Imperial Institute and the Reporter on Economic Products on the subject of this and another caoutchouc-yielding plant. Professor Dunstan, the Director, remarks:—

"The latex of *Urceola esculenta* furnishes a rubber which promises to be of some commercial importance, especially if it can be forwarded in large consignments of the quality represented by the sample now reported upon. The results of its chemical analysis prove this material to be a rubber of excellent quality, a conclusion which is borne out by the report of the brokers. It will be observed that the brokers compare it with "Tonquin" rubber, which is understood to be a mixture of latices derived from different plants, varying greatly in composition and quality. It would therefore appear that the rubber from *Urceola esculenta* might be able to successfully compete with the "Tonquin" material. I shall look forward to receiving further information from you on this subject."

The "further report," from the Conservator of Forests, Pegu Circle, concludes with a note that the cost of collection of the *Urceola* rubber is prohibitive, and no profitable industry can ever be developed in connection with it. Quite possibly the rubber cultivated as a sole product may not pay expenses, but it will generally be found that where wild rubber exists the native succeeds in making something out of it. The Burman, it is true, is not an enterprising person, but there is no reason to doubt that a large trade, in Chinese hands exclusively, but effected through the agency of the Selons or sea-gypsies of the Mergui Archipelago, has been established in Southern Burma in this and allied rubbers. Mr. Strettell, in bringing the rubber first to notice, gave his estimate of the working of a plantation. He began with a valuation of the article by a Rangoon firm, who quoted it at Rs. 200 per 100 viss, or about a rupee a lb. delivered in Rangoon, at which price

they were willing to take any quantity offered them. He advised Government to plant *Chavannesia* at 30′ by 30′ intervals over 400 acres of forest, making 48 plants per acre, or 19,200 plants in all. The gross value of the produce from these he reckoned at Rs. 38,400 per annum (2 lbs. per vine per annum). Allowing 12½ % for cost of collecting and preparing the rubber for market, he arrived at Rs. 39,400—4,800, or Rs. 33,600 net per annum, being 300 % return on the capital outlay, which he reckoned at Rs. 11,200 (Rs. 4 per acre per annum spread over seven years). The latter figure was almost certainly underestimated, and the former the reverse. But the question of cost of production and consequent return to capital has yet to be seriously dealt with, and its difficulties examined from the point of view of the planter who really wants to make the product pay.

The following extracts from the official report will show the experiments made by the Conservator of Forests and the results obtained, from which his unfavourable conclusion is drawn:—

"In January 1903 four men were employed for three days in tapping 60 Urceola creepers in the 1874 plantation of that species. The creepers varied in girth from 4 to 13¾ inches and 20 cuts were made in each creeper. The resulting latex was left to stand in zinc dishes. Coagulation commenced almost at once, but was not complete until after the lapse of a considerable time. A certain amount of moisture still exuded when the rubber was hung up to dry in April. About the 25th April the rubber was weighed and its weight was 5¾ ounces.

"In March 1903 four men were employed for three days in tapping the larger creepers in the plantation, including only two or three of those tapped in January. On this occasion no record was kept of the number of creepers tapped (the number was considerable), or of the number of cuts made in each, but to prevent immediate coagulation a little water was placed in each cup to dilute the latex. This resulted in a reduction of the proportion of scrap rubber. To the diluted latex a small quantity of a solution of alum was added with the result that the rubber separated out almost immediately as a pure white spongy mass. The waste liquid was poured off and pressure applied with the hand. After

most of the liquid had been removed in this way, the cakes were placed between cloths and pressed under weights. They were then hung up to dry and subsequently weighed at the same time as the rubber obtained in January. The weight was 7¼ oz. In both cases small zinc cups were used to collect the latex. At annas eight per day per man employed the cost would amount to Rs. 12 for 12⅛ oz. of rubber or nearly Rs. 15-6-0 per lb. It would appear that the yield constantly decreases with each tapping."

Considering the serious mischief which may be done by these and other creepers to the valuable timber of the Burma forests, and the amount of trouble thereby given to the Conservators, one has to discount a certain amount of prejudice against this plant. Nevertheless the experiments appear to have been conducted on careful and perfectly fair lines. The first point for criticism of them is of course the very high rate of wage paid to the collectors. If for eight annas (the current cooly-hire in Burma) we substitute three annas, which is the highest one would pay a cooly in Goa territory, the cost of production at once falls from Rs. 15-6-0 per lb. to a fraction over Rs. 5-12-0. That Rs. 15-6-0 is far too high the Forest Officer himself admits, for to his report he appends a note of tappings undertaken in 1900, the cost of which (two series) worked out to Rs. 2·53 and Rs. 5·20 per lb. respectively. The mean of these figures being Rs. 7·70, by the same substitution the average cost for Western India would work out at Rs. 2-14-6 per lb., or 3*s.* 10*d.*—a price still in excess of the London market value of the product.

Then a further suggestion can be made. Where valuable timbers are concerned, there is no reason why the vagaries of the rubber-vines should not be kept in check by treating them from time to time as is done in Malaysia, and with the Landolphias in Africa, namely, cutting them down and dividing the stem into segments, one end being heated to accelerate the flow

of latex. This extracts all the rubber possible, and the vitality of most of these plants being great, stool shoots soon spring up to take the place of the main stem.

Finally, it would be wise to discard the alum process of coagulation entirely, replacing it by that successfully employed by M. Pierre of Saigon in the case of Parameria glandulifera—see the note (following) upon that plant.

2.—CRYPTOSTEGIA GRANDIFLORA.

An Asclepiad. A lofty climber, probably not specially suited to Portuguese India, as it prefers a dry hot climate such as that of the Deccan. Branches stout, with a brownish bark. Leaves opposite, fleshy, dark-green, 3″ to 4″ by 1·5″ to 2″, coriaceous, glossy above, nerves many, spreading, arched, faint. Base of leaf acute; petiole 0·5″ to 0·66″. Cymes short, spreading peduncle and branches stout, hoary or glabrous; bracts caducous. Sepals 0·5″ to 0·66″. Corolla pale pinkish purple, tube and throat 1·5″. Long limb often 2″ in diameter; lobes acute. Follicles 4·5″ by 1″ to 1·5″, broadest near the base, straight, woody. Seeds 0·25″ long, oblong-ovate, compressed, narrowed upwards, coma 1·5″, very fine. Supposed to be a native of Madagascar or Africa. Grown extensively in gardens in the Bombay Presidency, and is common in the drier parts of the Deccan districts. Its latex is said not to be very abundant, but the rubber obtained from it vulcanises well. Has been recently valued at 3*s.* 6*d.* per lb.

The *Bulletin de Renseignements Coloniaux* for November 1904, contains an interesting if somewhat mysterious note upon this plant. It runs as follows:—

> The last Mail from Madagascar brings the news that a newly-arrived planter has had the good luck to discover, in the neighbourhood of Tamatave, a liana whose juice, coagulated by a process of which he keeps the secret, gives a gutta-percha (*sic*)

apparently of good quality. A business house of the Metropolis has bought two thousand kilos. of this new product in order to test on a large scale the first experiments made a few months ago on a lot of fifty kilos. of this stuff. The liana which yields this gutta should be found in considerable quantities in the forests of the West Coast, and if the experiments undertaken succeed, it is by thousands of tons that Madagascar can furnish the precious substance to France, and our lucky compatriot will speedily make a huge fortune.

A critic in the *Journal d'Agriculture Tropicale* (May 1905), acquainted with Madagascar and with botany, guesses that this plant can be none other than the *Lombiro*, a Cryptostegia, and enquires:—"If the stuff is really a gutta-percha, should not the first fifty kilos. have been sufficient to settle the question?" However, the subject has been taken up seriously, and the latest information to hand (*Journal d'Agriculture Tropicale*, July 1906) shows that this guess was correct—the plant is a Cryptostegia. It is reported to grow and to yield rubber (not gutta) equally well in a damp and a dry climate. It is a bush or a creeper according as is or is not given a tree to climb. The secret process of coagulation turns out to be the well-known one of admixture with water slightly warmed and flavoured with sulphuric acid. In Madagascar the plant grows so rapidly that it is ripe for tapping in its third year. But what tapping really amounts to is not stated—presumably the only way to get thousands of kilos. out of a liana is to cut it into segments and apply heat, as described above (under Chavannesia).

3.—PARAMERIA GLANDULIFERA.

This is a creeper similar to the first described, belonging like it to the Apocynaceæ, and inhabiting the same regions. Its rubber is of very fine quality, golden yellow in colour when fresh, closely resembling that of the *Hevea brasiliensis*. M. Pierre, Director of the Botanic Gardens at Saigon, describes it as forming a beautiful white rubber when the latex is thrown into a basin of hot water. It has been the subject of careful enquiry by

Mr. F. B. Manson of the Burma Forest Department, who reports a large export trade in it by Chinese collectors from Penang and the Straits, who visit the islands of the Mergui Archipelago, keeping their *modus operandi* as secret as possible.

The present writer has found this vine much more amenable to tapping than either of the preceding ones, and the rubber obtained from it of remarkable resilience. The rubber-vines of Burma and the Straits do not appear to have received anything like the attention from European enquirers that they deserve.

CHAPTER VIII.

CONCESSIONS OF LAND FOR RUBBER-PLANTING.

1.—TENURES IN BRITISH INDIA.

THE following chapter was added in April of this year (1906) to the rules in the Lower Burma Land and Revenue Manual to meet the increasing demand for lands for rubber-cultivation in that Province, and is now under consideration by the Government of Bombay as to its suitability to the case of similar concessions, should these be applied for, in Western India.

CHAPTER IV-A.

"*Grants and Leases of Land for the Cultivation of Rubber.*"

"29-A. Grants or leases of waste land not exceeding 1,200 acres in area for the purpose of planting rubber-trees may be made by the Deputy Commissioner, with the previous sanction of the Commissioner in any District of the Tenasserim Division, and in any other district specially notified by the Local Government.

"Then the area which it is proposed to grant or lease exceeds 1,200 acres, the application shall, with the recommendation of the Deputy Commissioner and the Commissioner, be submitted to the Financial Commissioner for his orders.

"29-B. The following special conditions, as well as the general conditions of Chapter III, so far as they are not inconsistent with the special conditions, shall apply to all grants or leases made under this Chapter, namely :—

"(1) The grantee or lessee shall, within five years from the date of the instrument of grant or lease, plant not less than 50 trees per acre of the area granted or leased ;

"(2) At the expiry of the twelfth year from the date of the instrument of grant or lease the number of trees growing on the area granted or leased shall not be less than an average of 150 trees per acre of the total area granted or leased, and shall be fairly distributed over the whole area;

"Provided that in computing the total area the land occupied by or appertaining to buildings erected for the purposes of the

grant or lease, and the land, if any, declared by an officer deputed by the Conservator of Forests for the purpose, at the instance of the Deputy Commissioner, to be unsuited for the purpose of growing rubber trees, shall be excluded.

"(3) The grantee or lessee may cultivate such other crops as he desires in addition to rubber-trees, but such cultivation shall be strictly subordinated to the cultivation of rubber-tree.

"(4) During the continuance of the grant or lease the average of 150 trees per acre of the total area, as computed in the proviso to Condition (2), shall be naintained.

"29-C. If at any time the Deputy Commissioner considers that a grantee or lessee is infringing any of the conditions imposed by Rule 29-B, he shall make such enquiry as may be necessary, and if he suspects that there is an infringement of Condition (3), he shall take the opinion of the Conservator of Forests as to whether the grantee or lessee is prosecuting the cultivation of rubber with sufficient attention.

"29-D. If the Deputy Commissioner considers that the grantee or lessee has failed to observe any of the conditions imposed by Rule 29-B, he may resume the whole or part of the area granted or leased. In the event of a partial failure by the grantee or lessee to observe the said conditions the area to be resumed shall be determined by the Deputy Commissioner, in consultation with the Conservator of Forests, on taking into consideration the extent to which the grantee or lessee has failed to observe the conditions.

"Provided that an order of the Deputy Commissioner shall not take effect until it has been sanctioned by the Commissioner.

"29-E. The term of a lease granted under this Chapter shall be thirty years, and the lessee shall have the right to a renewal for a further period of twenty years, subject to such revenue as may be prescribed under Rule 29-G.

"*29-F.* The land granted or leased shall be exempted from assessment to land revenue (which term shall in this Chapter and in leases issued under this Chapter be deemed to include rent) for a period of twelve years from the date of the instrument of grant or lease.

"*29-G.* After the expiry of the period of twelve years specified in Rule *29-F*, the entire area of the land comprised in the grant or lease (or such portion thereof as remains with the grantee or lessee) with the exception of any areas excluded under the proviso to Condition (2) of Rule *29-B*, shall be assessed to land revenue

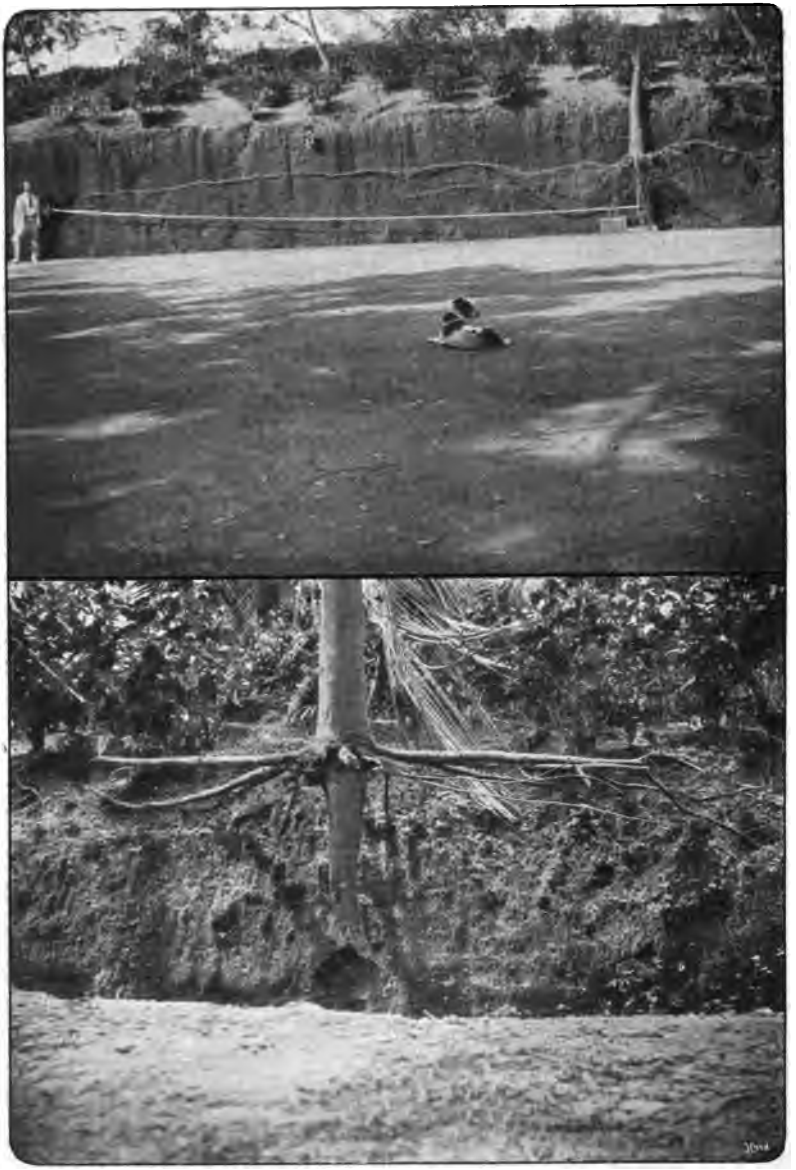


PLATE XIV (*a*).—Pará rubber; lateral rootlets extending 35 feet from the parent stem.

(*b*).—Root system of Pará rubber.

at such rates (not exceeding the highest rate sanctioned for the paddy land in the same district) as the Local Government may be general or special order prescribed. Land excluded from the computation under Rule *29-B* (*2*) as unsuited for the purpose of growing rubber trees shall after the expiry of the twelve years' exemption be liable to assessment at the same rates as similar land in the neighbourhood."

These rules are extremely liberal to the intending planter, and the only criticism they suggest is as regards the special conditions (2) and (4) in Rule *29-B*. 150 trees to the acre means intervals not exceeding 17 by 17 ft. It is quite certain that *Castilloa* trees, *Ficus elastica* trees, and in favourable conditions *Hevea* trees as well, require far more space than this. Wright, in his work on Pará-rubber, Chap. III, p. 25 of the 2nd Edition, mentions trees in the Straits planted 36 by 36 ft. whose branches have met in nine years. Nothing could be more instructive on this point than the illustrations (Figs. 19 & 23) with which we have been favoured by Mr. C. G. Northway of Elpitiya, Ceylon. The former of these shows a lateral rootlet of no less than 35 feet extension from the parent stem, and the latter gives a very fair idea of the habits of the plant as regards root-development, and in Ceylon planted 40 by 40 ft. in ten years. The condition moreover takes no account of the risk of contagious plant-disease in a plantation of close-growing *Hevea*, and stands in the way of one of the most promising measures of precaution—the establishment of "sanitary cordons" of non-rubber trees by interplanting in belts so as to isolate each block of *Hevea* from its neighbour. We trust that the stipulation, if not removed entirely from the lease, may be reduced in its requirements from a minimum of 150 to one of 100 trees per acre, noting that trees planted 20 by 20 ft. run to 109 to the acre.

2.—TENURES IN PORTUGUESE INDIA.

Rubber-cultivation has not yet come to the front in the State of India so prominently as to suggest to the Central Government any code of rules for its regulation.

Goa however possesses the nucleus of a *Hevea* plantation, in the vicinity of Ponda, and individual proprietors have of late put down small experimental plots of both *Hevea* and *Castilloa*. The very liberal and encouraging spirit in which the question of tree-cotton cultivation has been dealt with in the Decree of the Ministry of Marine and Overseas (20th March, 1906, published in the *Bulletin Official* of 24th April, 1906), leads one to suppose that this enterprise to will, should a case be shown for it, receive equally favourable consideration. In fact, though only professing to deal with the question of cotton-growing, the rules laid down for concessions of land are in no way incompatible with the development, side by side with cotton, of other and possibly more remunerative products such as that forming the subject of the present Notes. The preamble to the Order in Council, after reciting the advantages to the cultivator of cotton as a crop, not perhaps of the first order in point of profitableness, but still sufficiently remunerative to attract the capitalist and cultivator alike, goes on to describe the general facilities promised as regards improved means of communication, etc., and announces the rules in detail, thus :—

"*Art.* 1. (Refers to the Cotton-growers' Associations of Europe.)

"*Art.* 2. The regulation of concessions of land intended for cotton-growing in the overseas provinces will be subject to the following rules :—

"(*a*) The concessions will be made by lease, independent of public auction, and with the proviso of remission of ground-rent, which however will only come into operation when the holder shall have cultivated at least one-fifth of the area conceded to him ;

"(*b*) The amount of the ground-rent shall be 10 rèis per hectare ;

"(*c*) The concessions shall not exceed 1,000 hectares for each colonist or cultivator, the areas granted being in proportion to the means which the applicant shall prove himself possessed of, and having regard to the nature and situation of the lands ;

"(*d*) Except for lawful cause duly established in evidence, the lands conceded shall be properly brought into use within a term not exceeding five years, to be fixed in the title-deed of the concession, the holder being bound at the expiry of a term of two

years from the date of the said title-deeds, to have under regular cultivation at least one-fifth part of the said lands. Failure to carry out these obligations will entail the loss of the lands not thus brought into use by the holder, or the payment of an annual fine varying according to the circumstances of the case from 100 to 500 rèis per hectare or fraction of a hectare not thus brought into use, the parcels of land upon which for three successive years this fine has been incurred reverting to the State;

"(*e*) The concessions will be made by the Governors of the respective Provinces, independent of superior confirmation; they may not however be transferred or alienated in any way without the express authority of Government;

"(*f*) The holders will be subject to all such measures of legislation in force regarding concessions in the overseas provinces as have not been modified by the foregoing rules, they being however exempted from the obligation to furnish a security deposit;*

"*Art.* 5. The exemption from import duty in the overseas provinces of machinery, tools, and plant destined for agriculture and industry in harmony with Art. 4 of the letter of the law of 2nd September, 1901, continues to be in force, having regard to the decision contained in the Royal Warrant of 11th November, 1904;

"*Art.* 7. The Government is empowered to grant exemption from duty on material of transport, imported for the working of the productive centres of colonial cotton;

"*Art.* 9. The exemption from all taxation on the exploitation of cotton, agricultural or industrial, up to its transformation into bale, established by Art. 6 of the Decree with the force of law of 2nd September, 1901, applies to all the overseas provinces;

"*Art.* 10. All legislation to the contrary effect is hereby repealed."

It will be seen that the above rules, though constructed with special reference to cotton, are quite ample enough in their wording to cover the case of a mixed plantation of cotton and rubber; and, as will be seen from Chapter X of the present Notes, it is exactly such a plantation that holds out the best promise of success.

* In the case of foreigners applying for the benefit of these regulations, the question is now pending decision as to whether the conditions applicable to mining grants (involving an express renunciation of any claim based on or in any way resembling *extra-territoriality*, and possibly requiring naturalisation of the applicant as a Portuguese subject) should not be enforced.

3.—TENURES IN MYSORE.

The following order has been passed this year by the Government of Mysore, who are evidently alive to the revenue value of the concessions they make and the difficulty of obtaining suitable lands elsewhere, and leave no room for misunderstanding as to the meaning of the rules they frame for the guidance of rubber-planters:—

"The Government of H. H. the Maharajah, then, after premising that the present conditions on which they will entertain applications for rubber cultivation in the State are tentative, proceed to add that they are primarily intended for the benefit of local applicants, whether natives of the country or planters who have already settled there. Local planters, Government consider, are entitled to preferential treatment over others, inasmuch as they already own or manage estates in the State, and Government recognise that the coffe-planting industry has been beneficial to the State in the past, although it has been declining in recent years and has proved unprofitable to many of the planters. With regard to outside applicants, Government reserve to themselves the liberty to fix such terms as they may consider most advantageous in each case. The concessions to resident planters cannot be indefinitely continued without prejudice to the public interests, and these accordingly will only be in force for the next two years and will be withdrawn in the case of applications received after the 30th June, 1908. Such concessions will not be permitted by Government to be enjoyed by other than *bonâ-fide* applicants, about whose intention and ability to carry on rubber-cultivation to good purpose Government feel a real degree of assurance. In such cases Government will be prepared to grant land, not exceeding a maximum of 500 acres in any case, free of assessment for the first five years from the date of the grant, and at an assessment of Rs. 3 per acre on all land included in the grant, from and after the sixth year.

"No upset price will be demanded till the expiry of the first five years, when an upset price of Rs. 10 per acre will be recovered and the payment of the same will, for the benefit of the persons desiring it, be spread over a period not exceeding five years. The only condition that will be insisted on in the selection of land is that it should not be land which for the protection of springs or for the preservation of hill-sides or other well-marked natural features or on account of its containing valuable timber or being evergreen forest of the kind known as *Kan*, it is considered necessary to reserve to Government. All applications for land should be referred by the

Revenue Authorities to the Forest Department for investigation and opinion before recommendations are made to Government. If the block applied for adjoins a perennial river or stream, and it is not considered necessary to reserve the whole, a belt fifty yards in width should invariably be reserved on either bank. To avoid delay, the Conservator will cause the forest lands in the Malnad tracts of the State to be inspected and will draw up as soon as possible a list of the lands that may be given out for cultivation.

"To allow proper facilities for clearing the land without depriving Government of the value of the timber on them, Government direct that after land is made over to an applicant for cultivation he should give notice to the Forest Department in the September of each year of the extent and situation of the area he intends to clear and plant in the succeeding year. The Forest Department will arrange to cut and remove within six months of the receipt of notice all timber on the area likely to be cleared by the applicant. Each succeeding year a similar notice should be given the Forest Department.

"The Forest Department will not enforce its claim to any timber remaining uncut after the expiry of six months from the receipt of the notice in each year. Sandal should be strictly preserved, but with this exception the applicant will be free to cut trees, whether reserved or unreserved, on such areas. Forest, Police, and Revenue officers will have free access to the plantations. After the full upset price of Rs. 10 per acre shall have been recovered, a title-deed will be granted. Until receipt of the title-deed, no grantee will have the power of alienating any portion of the land granted. Alienations in contravention of the rule will render the grant void."

CHAPTER IX.

SELECTED ESTIMATES OF RETURN TO CAPITAL.

1.—HEVEA PLANTATIONS.

DETAILED estimates of cost of planting and return to capital outlay are not generally available, except in the prospectuses of newly-formed companies for the exploitation of rubber, where they may or may not be trustworthy according to the circumstances of each case. In the Chapter of these Notes dealing with *Hevea brasiliensis*, however, will be found an estimate of outlay, prepared by an official of the Ceylon Government, which has long been public property, and may, with the necessary modifications, be taken as guide to the preparation of a financial programme for a similar enterprise in Portuguese or British India. On the expenditure side it would perhaps be as well to increase its total, as many possible contingencies have not been provided for, and several items have not been too liberally dealt with. As an example of the former, a forest fire or a visitation of locusts—the latter in particular—may go far to vitiate the most carefully-drawn estimate; and in the regions best suited to rubber-cultivation, both in the Portuguese and Western British India, these two dangers together would constitute one of the most important factor in the calculation, were they calculable at all. But as they are not the only way to provide for them is to add a large enough sum to the cost of laying-out the plantation as will cover the doing of a considerable portion of the work over again should such a calamity occur. Again, in the estimate under review, the sums assigned for roads, tools, and plant, are one-tenth of the minimum likely to be required, and the money allotted to permanent buildings takes no account of store-houses or drying-rooms, not to mention machinery, an

indispensable item in the production of marketable rubber, up to the standard exacted from the modern planter. On the other hand the large sum shown as cost of land is not applicable to Indian conditions, as we have seen from the preceding Chapter; and in revising the estimate it may be re-appropriated to cover the deficiencies just referred to.

It will be noted that the Ceylon Forest Conservator's figures quoted, and for the matter of that, all the estimates set forth in Mr. Wright's book on *Hevea brasiliensis*, most of which are valuable and instructive as far as they go, are estimates of capital cost—not of profit-and-loss on the working of the plantation as a going concern. And one reason why the latter class of estimate is not more in evidence will be obvious to anyone who sets himself the task of compiling the available data into a prospectus and working out results. The returns to capital outlay give such fabulous figures of profit that check them as one may, one is often tempted to reject them as vitiated but some undiscoverable miscalculation.

As an example of the difficulty in question, take the estimated figure of Rs. 100,000 cost of completion in ten years of a rubber estate of 300 acres, and to get even with the locust and the raiser of forest conflagrations let us add fifty per cent. to its sum, starting with a capital of one and a-half lakhs. Now let us apply the available data, most of which is susceptible of direct arithmetical proof, the rest being results obtained by careful observers, or figures taken from mercantile and official statistics. They are—

(*a*) Trees planted 10 by 10 ft.—about 435 to the acre.
Do. 20 by 20 ft.— ,, 109 ,, ,,

(*b*) Gross contents of 300 acres 10 by 10 ft.—130,500 trees.
Do. 300 ,, 20 by 20 ft.— 32,625 trees.

(*c*) With allowance of 12 acres for space covered by roads and buildings, for unsuitable land in patches, and for failures—

@ 10 by 10 ft. ..	130,500	125,280 trees net contents.
less ..	5,220	
@ 20 by 20 ft. ..	32,625	31,320 trees net contents.
less ..	1,305	

(*d*) It is proposed, between the 8th and 10th years inclusive, to thin out the plantation from 10 by 10 ft. to 20 by 20 ft. by "tapping to death" every alternate tree, so as to leave the remainder to expand their crowns healthily according to their nature. Thus taking the stock of trees at the beginning of that period as 125,280, and extracting by the most violently effective means possible all the latex that can be got from one-fourth of them (31,320) each year, we reduce the stock year by year as follows:—

8th Year	..	..	125,280 trees balance (opening).
9th ,,	..	..	93,960 ,, ,,
10th ,,	..	..	62,640 ,, ,,
11th ,,	..	..	31,320 closing balance.

(*e*) Reported yields of dry rubber (low average—excluding So. American results) per tree tapped:—

Age of tree when tapped.	Moderate tapping year after year.	Tapping to death within 3 years.
8 Years.	1 lb.	6 lbs.
9 ,,	1½ lbs.	4½ ,,
10 ,,	2 ,,	3 ,,
11 ,,	2½ ,,	0
12 ,,	3 ,,	0

(*f*) Cost of collection and curing (mean of two estimates from Ceylon—Rs. 1·05 and Rs. 0·60 per lb.), say 13 annas per lb.

(*g*) Average European market rate of Fine Pará-rubber for the sixteen years shown in the charts given in the Introduction to these Notes, 3*s*. 8½*d*. per lb. Net market price in India obtainable by the planter (after deduction of 10 % for freight, agency, brokerage, etc.), Rs. 2-8 per lb.

Applying these data to the case of a plantation of 300 acres opened on a capital outlay of 150,000 rupees, planted out originally @ 10 by 10 ft. and thinned down to 20 by 20 ft. according to the programme detailed in (*d*) above, we frame the following estimates :—

8th Year.

Dr.	93,960 trees @ lbs. 6 per tree—563,760 lbs. @ Rs. 2-8,			Rs.	1,409,400
	31,320 ,, 1 ,, 31,320 ,, ,,				78,300
		595,080		Rs.	1,487,700
Cr.	Superintendence, say Rs. 6,000				
	Tools and Plant (Upkeep of) 2,000				
		8,000			
	Collection and curing 595,080 lbs. rubber @ As. 13—489,752				
	Rs. 497,752				
	Contingencies @ 5 % 24,888		522,640		
	8 Years' Dividend @ 80 % per annum		960,000		1,482,640
	Balance of Cash in Hand				5,060
				Rs.	1,487,700

9th Year.

Dr.	Cash Balance from 8th Year			Rs.	5,060
	62,640 trees @ 4½ lbs. per tree—281,880 lbs. @ Rs. 2-8				704,700
	31,320 ,, 1½ ,, ,, 46,980 ,, ,,				117,450
		328,860		Rs.	827,210
Cr.	Superintendence Rs. 6,000				
	Tools and Plant (Upkeep of) 2,000				
		8,000			
	Collection and curing 328,860 lbs. rubber @ As. 13—267,199				
	Rs. 275,199				
	Contingencies @ 5 % 13,759		288,958		
	Dividend for the Year @ 300 %		450,000		738,958
	Balance of Cash in Hand				88,252
				Rs.	827,210

10th Year.

Dr.	Cash Balance from 9th Year			Rs.	88,252
	31,320 trees @ 3 lbs. per tree—93,960 lbs. @ Rs. 2-8				234,900
	31,320 ,, 2 ,, ,,	62,640 ,, ,,			156,600
		156,600		Rs.	479,752
Cr.	Superintendence	Rs. 6,000			
	Tools and Plant (Upkeep of)	2,000			
		8,000			
	Collection and curing 156,600 lbs. rubber @ As. 13—127,237				
		Rs. 135,237			
	Contingencies @ 5 %	6,761	141,998		
	Dividend for the Year @ 200 %		300,000		441,998
	Balance of Cash in Hand		———		37,754
				Rs.	479,752

These figures appear too good to be true, but all we can say of them is that they are founded on actual experience as regards the detailed data employed, with a reasonably wide margin for contingencies, and if they do not work out correct in practice it will be curious to know what the unascertained factor in the case may be.

For the sake of comparison, another estimate framed on fairly cautious lines is here given; that of a new Company, the Burma Pará-Rubber Company, Limited, operating in the Mergui Archipelago. The nominal capital of this Company is four lakhs, of which three are to be called within the first three years of its existence. The principal data on which it reckons are as follows:—

Market price of rubber (European markets) ... 5/ per lb.

Cost of production *and* placing on European market... As. 12 ,,

Yield per tree at sixth year 8 oz. advancing annually by 4 oz.

Each acre to support 200 healthy trees, or 200,000 on 1,000 acres—the extent of the plantation.

The prospectus then goes on to say:—

"The output of rubber from the plantation in the seventh year is estimated at 100,000 lbs., being an average of 8 oz. per tree. The cost of manufacture, export and sale is estimated at 12 annas per lb. equal to Rs. 75,000. The value of the output taken at 3/- per lb. (half the present price) will be—

On 100,000 lbs., £15,000		Rs. 225,000
	Less Cost of Production ...	„ 75,000
		Rs. 150,000;

equal to 50 % on the capital called up, and the return to the shareholders should increase each year in proportion to the increased yield of the trees.

"It will be seen from the foregoing that as the trees come into bearing highly remunerative results may be expected.

"The capital expenditure in clearing, planting, and upkeep during the non-productive period is estimated at Rs. 270,000."

These estimates appear to be carefully drawn. Acre for acre, they provide a smaller working capital than the Ceylon Conservator considers necessary, and a good deal less than we have assigned in adapting the Ceylon project to the circumstances of Goa. The amendments that suggest themselves to certain items of the Mergui estimates affect both sides of the account so evenly that were one to make them, the final result would be much as stated in the Company's prospectus. For example, having regard to the high rates of wage current in Burma (where all labour is imported), 12 annas per lb., as cost not merely of producing but of placing the rubber on the European market, seems a low figure. But on the other hand, having regard to the high price of rubber for some years back and especially to the merely fractional proportion between plantation rubber and Amazon (wild) rubber in the world's demand (*vide* Charts I & II in the Introduction to these Notes), 3/- a lb. as a forecast of the price-current within the next ten years seems extremely moderate. So that if these figures prove incorrect in practical working, they will do no more than cancel each other, in all probability. Another estimated item which

seems moderate to the verge of timidity is that of the yield. But this again is balanced by the assumption that the Company can reckon upon a fully planted area of 1,000 acres, 200 trees to the acre (*i.e.* 15 ft. by 15 ft. intervals if uniformly planted), in bearing by the sixth year. This depends on many matters only to be ascertained by actual experiment. But even if it does not come to pass, the Company will in all probability get their estimated crop of rubber from a smaller number of trees, which is after all the main consideration.

2.—CASTILLOA PLANTATIONS.

We have here two typical estimates of the class "too good to be true," but whose accuracy or the reverse requires the test of actual experience. The first is that given by Rowland W. Cator in *Chambers' Journal*, October 24th, 1896, and embodied in the prospectus of at least one public Company. It runs as follows:—

"Supposing the plantation comprises five hundred acres the eighth year's profit would amount to the enormous sum of £44,337-10-0. And the yield increases every year, with no outlay except for weeding and harvesting. The gross capital expenditure for the eight years I estimate as under:—

Cost of 500 acres of land @ 5/ per acre	£	125
Surveying and procuring titles thereto	,,	100
Clearing land for planting	,,	1,000
Collecting seed and planting	,,	500
Eight yearly weedings @ £200 each	,,	1,600
Extras, implements, etc.	,,	300
	£	3,625
Interest on £3,625 for 8 years @ 5 % per annum ..	,,	1,450
Planter's expenses, cost of living, etc., 8 years @ £200	,,	1,600
Cost of gathering the eighth year's crop	,,	1,500
	£	8,175

"I have included in the above the cost of maintaining the planter during the eight years that should elapse before the *Castilloas* are tapped; but it should be borne in mind that when the trees are planted fifteen feet apart, coffee, sugar-cane, cotton, cacao, and other shade-loving plants, yielding yearly crops, may be grown between them, and their produce should maintain the planter. But

adding five per cent. interest, the planter's expenses, and the cost of harvesting, there still remains a net profit of £36,162-10-0. Estimating the value of the ninth year's yield at £50,000, and deducting £200 for the annual weeding, £1,500 for the cost of harvesting, £180 for interest, and £500 for the planter's expenses, the net profit for that year will amount to £47,620, a pretty good return for a net capital outlay of £3,625."

The public Company that decided to put these anticipations to the test, raised a capital of £400,000 sterling, and took over an estate, ready made, of 200,000 trees of eight years' growth. The estimates framed for the creation of this estate had already formed the subject of a report by the British Minister in Mexico to the Foreign Office in London, from which the following is a quotation:—

"Few are the plantations of India-rubber trees existing in the Republic of Mexico. The principal one is 'La Esmeralda,' in Juquila, Oaxaca, which has over 200,000 trees, eight years' old.

"The total expense for five years' cultivation of a Rubber-plantation of 100,000 trees will not exceed $25,000 Mexican currency (about £2,500). The yield of 100,000 trees at the first year's harvest will bring the planter $120,000, besides the product obtained from the corn, vanilla, bees, cacao, and bananas, raised from side planting. The net profit on the investment after deducting the entire cost of the land and all expenses up to the first year of harvesting will be $95,000 (about £9,500), and each of the succeeding harvests for 25 or 30 years will bring a steady income of over $100,000 (about £10,000). This is 400 % per annum net profit on the investment. These calculations are based upon the production of a five-year old tree, but this will be gradually increased every year for the next four or five years. These are the figures, based upon the yield from 100,000 trees:—

1st year	..	5-year old trees,	2	lbs.	per tree,	@ 1/	..	£10,000
2nd do	..	6 ,, ,,	3	,,	,,		..	,, 15,000
3rd do	..	7 ,, ,,	4	,,	,,		..	,, 20,000
4th do	..	8 ,, ,,	5	,,	,,		..	,, 25,000."

The history of the experiment is instructive. From its three hundred and fifty thousand *Castilloas* the figure to which it was proposed to raise the stock of 200,000 rubber-trees already on 'La Esmeralda' the Company anticipated a revenue in the first year of £87,500.

To which it hoped to add:—

	£
2 lbs. Chicle gum per tree @ 1/ per lb. from 250,000 trees,	25,000
6,000 tons of Cabinet timber @ £2 per ton net ..	12,000
Profit from cocoa, coffee, etc. (about)	5,900
	£130,400

Less—

Administration, Management, Reserves, etc.,	£35,000	
Debenture Interest	,, 14,000	49,000
Estimated Net Revenue ..		£81,400

When the Company went into liquidation, three years afterwards it transpired that its actual net revenue for that period was only £275, and that its safe had been stolen bodily with all its contents. It further appeared that it was altogether a doubtful matter whether the trees on 'La Esmeralda' were *Castilloa elastica* at all. As we have seen, the species of Castilloa are still in some confusion, and the mistake is not so absurd as it seems.

3.—FICUS PLANTATIONS.

In our Chapter V, we referred to a unique case—a plantation not a Government experiment but run on commercial lines for the exploitation of this tree alone. The report is about eight years' old, but is nevertheless of special interest:—

"The oldest caoutchouc plantation in the world," says the writer, "is perhaps one existing in the west of Java, in the province of Kranong. A former proprietor of the Pamanockan Tjiassan estate which is the biggest private property in Java, containing 540,000 Dutch acres, had most of his land under coffee until 1872. Finding the cultivation of this plant no longer lucrative, he planted some of the land up with *Ficus elastica*. The coffee plantations had already been more or less cleared of forest growth, so that the planting of *Ficus elastica* cost less than 30/ per acre. The soil of these coffee gardens had become useless for other agricultural purposes; and had not *Ficus elastica* (Karet) been planted in time, would only have become covered with poor forest growth. The trees were planted 8¼ yards apart, or 72 trees to the acre. The area planted was 72½ acres, containing 5,200

stems. The trees were first tapped when the plantation was 14 years old, and the yield for that and the six following years was:—

Year.	lbs.	Average oz. per stem.	Value in £.
1886	5,512	17	600
1887	4,954	15	540
1888	1,514	4	165
1889	..	..	..
1890	3,307	10	360
1891	6,113	18	387
1892	5,992	18	256
1895	3,197	10	411
Total	30,589 lbs.		£2,719
Average per annum per stem		.. 6 oz.	

"72½ acres thus, it is said, yielded in seven years a surplus of £2,719, or per acre per annum £5-8-0. The yield was 71 lbs. per acre per annum during this period. During the 23 years from the establishment of the plantation in 1872 till 1895 the net yield per acre per annum amounted to £1-12-10."

These figures deserve some attention. Granting that the land in question was abandoned coffee land, exhausted to all intents and purposes, and might therefore be easily planted up at 30/ per acre, the capital outlay only came to £108-15-0—certainly a unique figure for a plantation of 72½ acres. We are not certain what a Dutch acre exactly means, but from the figures employed we reckon it as about ¾ of an acre English, or 0·3 hectares. If this be so, $\frac{£2,719}{Yrs.\ 23}$ = 118 % per annum approximately—a very fair return to capital invested.

CHAPTER X.

SCHEME FOR A MIXED PLANTATION.

1.—REASONS FOR MIXING.

THE combination of rubber with cotton, in the case of a plantation created under the second set of conditions enumerated in Chapter VIII of these Notes, is of course a foregone conclusion. But there is no practical objection to it whatever, so long as the cotton is kept clear of overhead shade (the writer in *Chambers' Journal* quoted in the preceding Chapter was mistaken in describing cotton as a shade-loving plant) and the lateral shade it gets is not such as to deprive it of its fair share of sunlight—all that cotton wants being a screen from high winds and a sufficiency of trees around to give it a good supply of leaf-mould. The main idea of a mixed plantation being to establish a state of things under which pests may have the least possible facility for spreading, the first point to be noted is the liability of plants of the same age to the same class of pest—the diseases of infancy in plants being quite distinct from those of maturity, and *vice versâ*. Where (as in the case of Portuguese India at present) land is abundantly available, it should be a very easy matter to arrange that the plots or blocks of trees of the first year should be separated from those of subsequent years, either by leaving wide belts of original jungle in which later clearings and plantings can take place, or by cultivating in contiguous blocks plants of different species.

2.—SUGGESTED COMBINATIONS.

Looking therefore to rubber as the staple crop of the plantation, we would recommend, in order to at the same time secure a reserve crop in the event of bad luck with rubber, and a protective cordon should infectious disease

show itself in any block of the rubber plantation, that *Hevea*, *Castilloa*, *Ceará*, *Hancorinia*, or *Ficus* be planted in combination with one or other of the following :—

Tree-cottons—

(*a*) Gossypium peruvianum;
(*b*) Eriodendron anfractuosum;
(*c*) Bombax malabaricum;

Oil-trees—

(*d*) Melia azadirachta (nim);
(*e*) Aleurites moluccana (jangli-akrot);
(*f*) Jatropha curcas (jangli-erandi);
(*g*) Schleichera trijuga (kosumb);
(*h*) Sterculia foetida (puna);

Other rubbers—

(*k*) Two or more of the above-named rubbers;
(*l*) Belts of Chavannesia, Cryptostegia, or Parameria trained upon Manihot or Ficus;

Papilionaceae—

(*m*) Erythrina lithosperma (dadap);
(*n*) Dalbergia sissu (shisham);
(*o*) Cajanus indicus (tur).

The advantage of combining rubber with a cotton is that the latter comes into bearing so much earlier that the planter has not to wait years for returns to his outlay. Cottons of the *Gossypium* series will yield, with average good luck, within the first twelve months. *Eriodendron* and *Bombax* will take longer, and being silk-cottons their crop is not so valuable. Of the two, *Eriodendron* is preferable, as its pod remains on the tree so that it can be gathered, whereas *Bombax* pods burst as soon as they are ripe and scatter their floss over the ground, soiling it before it can be collected.

The oil-trees are a study in themselves. This list of them is by no means exhaustive, even for Goa, no mention having been made of such important trees as the *Pongamia glabra*, the *Hydnocarpus wightiana*, the *Calophyllum inophyllum*, or the *Garcinia indica*, anyone of which, properly handled, might be made a valuable source of profit in itself. The five trees named are particularly

rich in oil, and the first of the series (*Melia azadirahta*) is an excellent light shade tree, putting forth more and more leaves as the season gets hotter. The *Aleurites moluccana* is the source of the oil known in European commerce as "Artists' oil," at present obtained almost exclusively from the South Sea Islands. It grows so very freely wherever planted in Western India, and gives so very little trouble, that it would be well worth attention as a subsidiary crop to rubber in Portuguese India. *Jatropha curcas* is practically a weed in many places, but being a small evergreen tree would serve to store moisture in the vicinity of the rubber-trees, and its leaves, trimmed and dug into the soil, ought to have a certain value as green manure. Planted in the intervals between *Castilloa*, it would have a special value, as *Castilloa* after the third or fourth year, is all the better of lateral shade, and *Jatropha* planted at the same time as it would get just to the right height in that time to shade the stem without molesting the crown of the *Castilloa*. *Schleichara trijuga* is a tree not unlike the common soap-nut (*Sapindua trifoliatus*) for which it may easily be mistaken, but yields an oil highly valued in the European market (Macassar oil). And *Sterculia foetida* is too well-known in Goa to require much description. It is a giant tree and should be very useful in Hevea plantations if planted as a wind-belt. Its seed is singularly rich in oil.

Coming to the possible combinations of rubbers, it may be noted that *Hevea*, *Castilloa*, and *Ficus elastica* will grow side by side in most situations, and *Ceará* will not refuse to grow where they do though it will also grow in situations where they cannot thrive. It is for the planter to decide for himself whether he will disperse them haphazard through his estate, or form blocks of one adjacent to blocks of another species. It would seem a good plan to confine one species, say *Hevea*, to a hectare block, and let the adjoining block be of *Castilloa*, so that the *Heveas* and the *Castilloas* only touch at one narrow corner each,

draught-board pattern, the object of course being to check the spread of infectious disease from one block to another. To make this still more certain, the sides of the hectare (or in the case of a very large plantation the sides of a four-hectare block) might be planted out with avenues of *Ficus elastica* or *Manihot glaziovii* so as to form each into a compartment quite isolated from its neighbours containing the same species.

The idea of item (1) is that belts should be formed round the units (be they hectares or four-hectare squares), composed of trees of a second or third grade rubber, such as *Ficus* or *Manihot* with rubbers of the creeper class trained upon them. These would in time become impenetrable fences, and effectually keep cattle, deer, and pig out of the plantation. The same use might be made of the first two trees of the list of Papilionaceae, the former of which (both in fact) furnishes a most valuable green manure by means of its loppings, dug into the ground. Such too is the main use of the last-named plant on the list.

3.—MISCELLANEOUS PRECAUTIONS.

The question of fire-protection is one that requires the most careful consideration, whether the plantation be one of *Hevea, Castilloa,* or other rubber. A cognate matter is the protection of the soil from excessive evaporation in the early days of the estate. M. Leon Hautefeuille, of Saigon, who visited India a few years ago, has left on record a useful suggestion which occurred to him when inspecting Agave plantations in Cuba, specially liable to the ravages of fire through the prevalance, in the districts around, of a coarse grass of the Andropogon type. His idea was to suppress this grass, within the limits of the plantation at least, by cultivating in breed fire-lines (20 metres he considers by no means an excessive width, and we quite agree with him—in windy districts, where flames are liable to be carried high in the air, that distance might with advantage be doubled) a thick crop of some succulent

trailer—the sweet potato for example. "This plant," says he, "appears to furnish the band of verdure necessary, it is pretty tenacious and resists well those lapses in cultivation so common on Henequen plantations (*Journal d'Agriculture Tropicale*, May 1902). M. Hautefeuille's idea had been applied with success to the case of *Castilloa* plantations in Mexico. H. C. Pearson, of the New York *India-Rubber World* (Rubber planting in the Isthmus of Tehuantepec; New York, 1903), says that on one estate visited by him the owner has put down sweet-potato and let it straggle all over the ground between his *Castilloas*, thereby choking off all attempts of ill weeds to invade the estate. Another planter has attained the same result by turning loose upon the soil the vigna (Dolichos) catiang and the Florida velvet bean (*Mucuna pruriens*, var. *utilis*)—a useful variety of one of our most pestiferous weeds in India—the *kuhila* of Western India. The special merits claimed for these plants is that they not only choke off weeds and grass likely to carry fire, but furnish a marvellous fertiliser when used as green manure. The *Journal d'Agriculture Tropicale* (November 1901) states that the latter plant gives the equivalent of 560 kg. per hectare, or about 468 lbs. per acre, of nitrate of soda. There would seem to be no special objection to the vigna in a rubber-plantation, but with all the Papilionaceae to choose from (all having the property of assimilating nitrogen from the air), one would prefer rigorously to eclxude the *kuhila*—a plant likely to be as injurious to the rubber trees of the plantation as to the labourers in it. My own suggestion, having regard to local conditions in and around Goa, would be to plant the fire-lines, and perhaps the intervals between the rubber-trees as well, with a combination of *Vigna*, *Crotalaria*, or some innocuous Leguminosa, with a liberal proportion of *Alocasia*, *Colocasia*, or other fleshy tuber, whose large juicy leaves would keep the soil moist and resist creeping fire, at the same time providing a food-supply for the coolies on the estate. Against the risk of overhead fire, carried by high

winds from tree to tree, such as is often seen on the Western Ghâts, the best precautions are wider fire-lines and thicker belts of the *Ficus elastica, Aleurites moluccana,* and *Jatropha curcas* type of tree. Needless to say all dry leaves found underneath the rubber-trees themselves during the dry season should be swept together and burnt from time to time in a safe place under careful personal supervision.

Another matter which will claim the early attention of the planter is the eradication of dead stumps. In an article which recently appeared in the *Ceylon Observer*, and has now been reproduced in the text of a paper of Notes issued by the Committee of the Peradeniya Rubber Exhibition of 1906, the case is stated thus :—

"A great difficulty besets the planter when clearing virgin forests or jungle for rubber or other planting operations where he has to uproot or destroy the stumps of large trees. Small tree stumps can be uprooted, but the stumps of forest giants with basal girths of 6 feet, 8 feet, and even 10 feet or more, require tremendous power for uprooting, and are by no means easy to destroy. Leaving them in the ground is unsatisfactory, for uprooted stumps can be used for fuel or turned into charcoal. And a more serious thing is that dead stumps left in the ground to decay are hot-bed for the breeding of fungus diseases and various tree pests such as termites. The latest root-disease of rubber, the worst that has so far been reported in the Eastern Tropics, is *Fomes semitostus*. Of this disease, which breeds in rotting stumps, Mr. H. N. Ridley, Director of the Singapore Botanic Gardens, says :—'This fungus is very common on decaying stumps of all kinds of trees, and is, properly speaking a dead wood feeder, but, like a number of allied species, attacks also living trees. As a disease fungus, I would class this as contagious, as opposed to an infectious fungus, as it appears to spread from root to root in the ground without being dangerously dispersed through its spores. A dead stump may be attacked above or just below the ground, and the mycelium spreading along the dead roots may come into contact with those of a living tree, and so the attack is spread. . . . The infected trees should be destroyed and the roots dug out, every bit of dead root or decayed timber being removed.' Mr. Herbert Wright, writing of the disease, also says that the uprooting of all dead stumps is necessary.

"The Committee of the Rubber Exhibition have therefore done wisely in recognising the importance of finding an efficient means for dealing with tree stumps in new clearings, etc. The writer recollects reading, two or three years ago, of a good means for destroying or uprooting stumps in the *Agricultural Gazette of New South Wales* (?); possibly some reader of these notes may have access to a file of this paper and be able to look it up; its reproduction in the *Ceylon Observer* or *Tropical Agriculturist* might be of service."

We have not had access to the Gazette referred to, but in the work of M. Ringelmann, Director of the Experimental Station of Agricultural Machinery in Paris, entitled "Travaux et Machines pour la Mise en Culture des Terres" (Paris, *Librairie Agricole de la Maison Rustique, rue Jacob*, 26), all available information on the point will be found. And in the file of the *Journal d'Agriculture Tropicale* containing Nos. 23 and 24 of May and June 1903, a resumé of Mr. Ringelmann's chapter, with illustrations of types of machine, hand and power-driven, is given. This may prove a heavy item in the estimate of cost of laying-out an estate, the class of engine likely to be required in dealing with virgin forest being costly to work, as large teams of oxen will be required. The most efficient of these, judging from the descriptions and diagrams given is the "Cyclone Windlass," or, as M. Ringelmann calls it, the "Dessoucheur Americain," an American invention. It is a ponderous machine, but not expensively constructed, and it works by means of a cable on movable pulleys which can be shifted about and applied to all the stumps within a ten-hectare clearing without requiring a change of position of the windlass itself—an important practical consideration, as anyone conversant with forest engineering will readily recognise.

Occasionally it may happen that in spite of all precautions considerable areas of planted rubber will be laid waste by the invader, be he locust, fungus, or insect pest, leaving here and there a solitary survivor of the general

debacle. To the planter who knows how to turn misfortune to account, this will present a valuable opportunity. The trees that remain presumably either possess or are in process of acquiring an immunity which ought to persist in their descendants. To secure this, their seed should be carefully collected and sown apart from that of trees not exposed to the ravages of the enemy, and the comparative results studied with equal care. If this is done as it should be done, the planter will find himself the lucky monopolist of a source of seed-supply far superior to any not thus tried and selected.

CHAPTER XI.

LESSONS OF THE CEYLON EXHIBITION, SEPTEMBER 1906.

THE preceding chapters of these Notes were in type before the present writers had become aware of the projected Rubber Exhibition at Peradeniya, and as they were in the hands of the publishers before the opening date, the writers hesitated to undertake what would probably mean the re-casting of the whole of their work at the eleventh hour. It was therefore decided to let the portions already written stand, with a correction here and there, this Chapter being reserved as a kind of appendix in which to note down the addenda and corrigenda to their earlier text.

It may be as well here to anticipate an objection. The lessons of the Exhibition cover so vast a field, and deal with so many abstruse technical and scientific points that it would appear presumption on our part to attempt their discussion in a single chapter. Perfectly true; but the most important lessons for the planting community to which the Exhibition owes its origin, and to whom as a body the lecturers addressed themselves, are those dealing with the stage of rubber-production, partial or complete manufacture, the requirements of the rubber-market, and so on. Whereas the clientele to which this book addresses itself is one at a more rudimentary stage of existence altogether; and at present chiefly interested in the establishment of rubber-plantations in regions not hitherto opened to that industry. We are fully alive to the truth of M. Georges Ohnet's dictum, "industrialisez vos produits," but for those who are fortunate enough to have arrived at the stage where this advice is appropriate, we understand an official handbook dealing with the Exhibition as a whole is in preparation, and we do not desire to trespass upon what is really its particular province.

2. The first question raised by the Exhibition, however, is one regarding which both Ceylon and Indian planters find themselves upon common ground; that of a threatened over-production within a period variously reckoned as from four to ten or twenty years hence, with the natural result of a serious fall in the market price of their commodity. So intimately connected with this question as to really form a part of it is that of the competition of Government—not in Ceylon or the Straits it is true—but in certain Provinces of British India—in the cultivation of rubber as a forest product and for revenue purposes. It may be remembered that when Lord Curzon in 1900-01 decided to plant 10,000 acres of rubber in the Tenasserim Division of Burma, his action evoked a strong protest from the Ceylon Planters' Association to the Secretary of State for the Colonies, but without result as far as any reconsideration of the resolution was concerned. Much surprise has been expressed in planting circles in Ceylon and elsewhere regarding the memorial of the Bombay Chamber of Commerce referred to in the opening chapter of these notes, actually urging on Government the duty of producing rubber! But so long as the practice of Government is to treat such experiments as a branch of forestry and tack them on as an unremunerated addition to the day's work of the already harassed District Forest Officer, the planting community need have no serious uneasiness as to danger in that quarter.

This particular item, though discussed outside, did not, it may be mentioned, form part of the official programme of the Exhibition lectures. But the general subject of over-production was the text of one of the most interesting papers of the series. Mr. Herbert Wright on the 17th September addressed a large audience of planters and their friends, opening the case for our common foe with the assumption that 65,000 tons (less 5,000 tons of plantation rubber), or 60,000 tons net, represented the

world's present annual consumption of rubber. Allowing 20 % as the average impurity of wild rubber (plantation rubber being taken as practically pure), this figure in terms of pure rubber stood for 48,000 tons. We note, en parenthese, that a writer in the *Financier*, evidently possessed of some acquaintance with the subject, puts the figure rather higher. Mr. Wright, in his lecture, went on to estimate the present (1906) area under rubber at 250,000 acres (the writer in the *Financier* puts it at rather less), of which 80,000 acres were actually in bearing; figures based on official returns but questioned by one or two practical men present as possibly higher than the actual facts—an error on the safe side however—so if an error let it pass. Anticipating the doubling of the net demand within the coming ten years, Mr. Wright drew up and presented to his audience tables showing that the acreage of plantation required to meet the demand (thus enhanced) by the year 1917 would not exceed 960,000 acres, whereas in Africa, South America, and elsewhere, concessions were being talked of which measured thousands of square miles, over and above the extensions contemplated in India, Africa, and Malaysia.

This was certainly a matter for serious consideration, and its gravity was accentuated by the facts and views of the speakers who followed. Notably by Mr. James Ryan, who drew a parallel between the prognosticated fate of rubber and the actual events in the history of tea. The moment the output of the tea estates exceeded by 10 % the world's demand, the world's price for that commodity fell by 25 %. The speaker went on to emphasise the point that the situation his audience were themselves engaged in creating was that between 1910 and 1913 a huge volume of rubber would be hurled on the markets at once, with effects exactly comparable with those of a similar planting operation (in quinine) some years ago. Another comparatively unrecognised fact bearing on the same question was presented by Dr. Christy when speaking of

the *Funtumia elastica*. This tree, it appears, is unlike other known rubbers inasmuch as it is gregarious and tends to form natural plantations of from 200 to 300 trees to the acre, to the exclusion of other vegetation. The direct competition of Nature on a large scale is certainly a factor in the case for or against the rubber-planter.

We hesitate to controvert conclusions presented to us upon so high practical authority as that of the speakers in question, notwithstanding the express invitation tendered to the audience to frame their own statistics and that the results. This challenge has already been taken up by the *Financier*, who is at least emphatic if not altogether convincing as to the improbability of any immediate glut. The present writers have before them estimates worked out eight years ago, when rubber prices were far lower than at present, for the establishment and management of a plantation in Tenasserim, Southern Burma, upon the basis of a market price of only 2/ per lb. as against the present rate of from 4/ to 5/ 6*d*., and on a lower average yield per tree than present-day results would entitle the framers to assume. Notwithstanding this, and also with a labour rate nearly double that current in Western India, the estimates in question showed a handsome profit. It is true that they never had a chance of being tested in actual practice, and may possibly have been under-capitalised against unknown contingencies, but we have reason to believe they cannot have been very far from the truth, the obstacle to their execution being purely the failure of the promoters to get from Government the concessions applied for, these having been reserved for development by the agency of the Government Forest Department in pursuance of the decision of Lord Curzon above referred to (the subject of the Ceylon Planters' protest). But as events have proved, the planting community have had no cause for serious alarm, as but little has been heard of the undertaking since, despite the fact that the

Government plantation started with an area fully stocked with mature trees covering 56 acres and capable of extension to ten times that area as far as suitable land went. Some portion of the land originally reserved has since been acquired by the Burma Pará Rubber Co., Limited (*vide* estimates reviewed in our Chapter IX). This Company assume an average market price of 3/ (an increase of 1/ on the original figure of 2/ per lb.), but as market rates during the past year have exceeded 6/ it is clear that a fall in price of 30 % or 40 % can be faced without the fear that the planter will not get his living wage out of his venture; which is after all the main issue.

3. Returning to the Rubber Exhibition itself, the next surprising discovery presented to us was the marked revival of interest in Ceará rubber. It is still true that in quantity the yield of the *Manihot glaziovii* leaves much to be desired, and cannot compare with that of *Hevea*, as many a planter twenty years ago found to his cost. The wound-response principle is inoperative upon this tree. But notwithstanding these manifest disadvantages, one was certainly unprepared for the very high quality of the exhibits of Ceará rubber displayed at the Show—more than one specimen being of far greater resiliency and toughness than the best Pará biscuit or sheet shown. The present writer was moreover fortunate enough to discover what for many years he has sought in vain—a practical planter who could assure him that Ceará rubber cannot merely be made of high quality but turned out at a cost sufficiently below market price to yield a fair return. This seems now established beyond reasonable doubt, one planter giving from personal experience cost of production as 1/ and selling price as 5/ 7*d*. It should be mentioned at the same time that by means of appropriate washing machinery Ceará planters have been able to get rid of the sickening smell that characterises hand-made rubber from this tree.

4. We were disappointed not to find Castilloa so highly appreciated in Ceylon as we expected, and also to find that the facts fully bore out the statement of certain writers (cited in a preceding chapter) that Castilloa at low elevations, after a few years of fair growth, becomes etiolated and useless. A short personal inspection of the trees of 20 years' growth in the Heneratgoda Botanic Gardens was sufficient to establish this point.

We have already referred to the doubt expressed by Messrs. Koschny and Pittier de Fabrega as to whether the Ceylon Castilloa is really the best available variety, and this doubt seems rather accentuated than otherwise by the intolerance the Ceylon trees shows for sea air and low elevations. An article quoted by us in a previous chapter, taken from the New York *India-Rubber World* of February 1900, which though unsigned contains internal evidence of a practical knowledge of the subject, states positively that the tree flourishes best from sea-level up to 1,000 feet, and the complement of this statement is to be found in Mr. Koschny's suspicion that the tree we have is the *Castilloa costaricana*, a comparatively worthless tree growing in Central America between 1,000′ and 3,000′. That the tree, whatever it may be, is not absolutely worthless, has no doubt been fully established, but the point is of sufficient interest to merit a personal comparison of specimens which we hope to make later on in Central America.

5. Of the greatest interest to the rubber-planter in India was the lecture delivered 15th September by Mr. E. G. Windle, and the Pará rubber exhibits grown at high elevations to which he referred from time to time by way of illustration. It has been so long accepted as a foregone conclusion that, for Pará rubber at least, an equatorial climate (high temperature and continuous moisture) are indispensable, that nothing short of the *fait accompli* and ocular demonstration of it could shake the common belief. All this has had to go, however. We

have now seen Pará rubber, extracted from trees grown on the Shevaroys at 3,500 feet, far superior in texture to that grown in the ideal climate of Penang or Singapore. The equatorial atmosphere of those places may and probably does force the growth of the plant, and on the other hand the thin chilly air and prolonged droughts of the South Indian hills retard it; but the tree grows there nevertheless, and—what is most important—the rubber from the high lands is tougher and more resilient than that from the lower. There can be no doubt that the tree stands without difficulty an absolute drought of five months' duration. Mr. Windle indeed questions whether indeed it does not benefit by the normal Indian dry season. Possibly it effects a natural selection.

In the course of the discussion which followed, some useful suggestions were thrown out as to selection of seed so as to secure the perpetuation of the best adapted varieties, and of those richest in yield. Separate nurseries for the classification of the plants were advised. It appears that in the Straits they are already alive to the necessity for this, and are taking the precaution of tying paper bags on the seed-pods before they ripen so as to ensure the exclusion of seed from poorer trees which would certainly occur were all the trees allowed to scatter their seed on the ground indiscriminately. Dr. Willis recommended planters to go a step further and cut out the trees known to be inferior so as to bar cross-fertilisation of the better trees adjoining them.

6. Among the exhibits of direct interest to the new planter alone, was conspicuous a series of wardian cases, three in number, shewing, (i), the seed newly planted in a compost of leaf-mould, vegetable charcoal, and moist soil; (ii), the same quantity of seed similarly treated, but at the stage of germination; and (iii), the young plants in full leaf reaching to the glass roof of the case after a journey of three weeks' duration, including several days' delay in a warehouse. A very ingenious and apparently

sound device for transporting such seeds for shorter distances so as to allow of their germination by the way, was by placing them in a case, layer by layer in the same compost as described above, separated by sheets of brown paper. This would seem a most useful plan for adoption in an estate where there is liability to delay at critical periods, as for example the coincidence of some native festival with the time of sowing the newly-gathered or newly-received seed.

7. Though not absolutely essential to the case of the newly-started plantations we are concerned with, it may be of interest to note certain matters connected with the preparation of rubber which obtained deserved prominence at the Show. It seems that the form of rubber known as biscuit, though susceptible of most artistic treatment, does not find favour in the London market, block or sheet being reported preferable. It was suggested that blocking one's rubber might raise the suspicion that the interior had been filled with "tacky" rubber, but this was shown to be an almost impossible and suicidal fraud, as rubber infected with tackiness would leaven the whole mass and betray its presence long before the consignment reached the brokers. In this connexion, the great compression exerted upon the first layers of rubber formed in the Amazon smoking process by the superposition of the subsequent ones was a notable point. Not merely was the interior compressed but its resiliency increased to a remarkable degree—a matter to be studied and made the subject of further experiment by those interested in making the best of their products.

The remarkable success of the proprietors of the Lanadron Estate, Johore, in the manufacture of block rubber, has led to their giving the planting community at large the benefit of their experience—a most valuable gift, seeing that not only has this estate taken gold medals both at the Singapore and the Peradeniya Exhibitions but now commands the highest price of any rubber in the market.

We are indebted to the *Ceylon Observer* and to Mr. Herbert Wright for the following communication, setting forth the whole process of manufacture of what promises to be the rubber of the future:—

BLOCK RUBBER.

METHODS OF MANUFACTURE AND PREPARATION.

By Francis Pears, Lanadron Estate, Johore.

Seeing the attention this has attracted both at the Singapore Agri-Horticultural Show and at the Ceylon Rubber Exhibition, it would not seem out of place to fully explain the points in its favour and the details of its inception, as claimed by the makers. The Prize "Block" was manufactured by the Lanadron Estate of Muar, and the awards made by the Judges of both Exhibitions are fully confirmed by the buyers at Home who value this method of preparation at 3 pence per lb. higher than the best Sheet or Crêpe.

This will, of course, have the effect of inducing many planters to take up this method of preparation, and it is to be hoped that in doing so they will recognise that it requires good machinery and that good "Block" is not to be manufactured by immersing Sheet or Biscuits in hot water and hydraulic pressing. This would only imitate it in appearance and not in quality.

The Manufacture of "Block" by the Lanadron Estate was conceived, in the first instance, as a means of turning out a rubber of standard uniformity in a practical manner, and one which would commend itself to those manufacturing rubber on a large scale; also to be a handy form for shipping and for storage at Home. That this has been accomplished must be apparent to everybody. Added to this the improvement in the quality undoubtedly establishes this as the best means of manufacturing raw rubber hitherto employed. In considering any new methods referring to the treatment of raw rubber, there are certain axioms to be considered, the most important of which are the following:—

1. Uniformity.

2. The eradication, as far as possible, of organic, and the complete removal of inorganic, impurities in the latex.

3. Acceleration during manufacture to reduce to a minimum exposure to the air.

4. Small surface exposed after manufacture.

Rubber manufactured with a view to these principles, besides having the characteristics of a good commercial rubber, will give a system which would appeal to anyone who takes an intelligent interest in this industry and is desirous of establishing a factory organisation on up-to-date principles, and where manual labour will be reduced to a minimum.

Coagulating Latex in Bulk.

1. Respecting uniformity, the only way to accomplish this is to mix the latex and coagulate in bulk. It has been suggested that the latex from trees of different ages should be kept separate, but this proposition is not one that could easily be carried out in practice. It would be much better to start with the uniform standard; and if old trees really do give a superior latex, the product of the estate must gradually improve with age. It has not yet been proved conclusively that the older the tree the better the rubber, although there are many indications pointing to this conclusion.

Washing the Freshly-Coagulated Latex.

2. The eradication, as far as possible, of organic and the complete removal of inorganic impurities in the latex. The only way to effect this, as everybody who is interested knows, is to wash the freshly-coagulated latex on an ordinary washing machine, such as manufacturers use at Home. In fact it is the only practicable method of reducing coagulated latex in bulk to uniformity of size, at the same time thoroughly washing every particle of rubber and removing all mechanical, besides a good deal of the organic, impurities. Tackiness, of which we have heard a good deal lately, and also mildew are a species of micro-organisms and, although of frequent occurrence in biscuits, seldom if ever occur in properly washed crêpe. This is strong testimony to the fact that washing freshly-coagulated latex removes some of the organic impurities which are detrimental to the keeping properties of raw rubber. Whether in addition to this it may be advisable to impregnate the latex with some antiseptic, such as smoke (creosote), formaldehyde, etc., is a matter for further experiment.

Vacuum Drying.

3. Acceleration during manufacture to reduce to a minimum exposure to the air. Despatch during manufacture can only be accomplished by accelerating the drying process, as hitherto this has occupied periods varying from a few days to as many weeks, with exposure all the time to the action of the air. Vacuum drying is the only practicable solution to this as it combines two very essential points, *viz.*:—rapidity, without any exposure to the air. By this means it is possible to dry the rubber in two or three

hours. Exception has been taken to the use of Vacuum dryers, as making rubber sticky, but this is only a matter of temperature which can be regulated mechanically. It is certainly rather a delicate operation and requires a man in charge who thoroughly understands the principles of the machine.

4. Small surface exposure after manufacture. After removal of the crêpe from the Vacuum drier it is in a pliable condition in consequence of not being subjected to the hardening influence of air drying (oxidation). In this state it is easily pressed into any convenient shaped "block," and the whole forms a perfectly homogenous mass, hermetically sealed, with a minimum surface exposed to the air and light.

A smoking machine invented by Messrs. Brown and Davidson of Talawakele, the use of which upon the uncoagulated latex was to be preceded by filtration through the Macadam centrifugal strainer, was a conspicuous feature of the Show. As it would seem probable that this device will become of permanent utility we borrow the *Ceylon Observer's* description of it:—

"A metal cylinder about six feet in height and three to four in diameter, running on wheels and opening on hinges to admit of the interior being readily got at. Inside is a central column on which are a series of baffle-plates, down and over which the latex runs, thus causing it to flow over a comparatively large surface while exposed to the action of the smoke. At the top the fresh latex is poured in through a sieve and runs through a set of channels which make it spread evenly over the surface. The smoke from the slow combustion furnace in which creasote-producing fuel is burned passes into the machine at the base and is cooled before it reaches the latex. By a series of inverted blades it is made to fill the machine with a dense column of smoke. When full, the latex is poured in at the top and is run at the bottom into a receiver. When we saw it working, the latex, after being passed five times through the machine, was still quite cold and had a strong smell of creasote. The machine on being opened was full of smoke. The metal baffle-plates were cold and no latex was coagulated in the machine."

If creasote-yielding wood or nuts such as *Attalea excelsa* are not procurable, the latex it is said can be mixed with a 10 % alcoholic solution of creasote before smoking it over ordinary wood though it does not seem

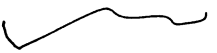


PLATE XV (*a*).—Switching-bill, and post hole digger for transplanting seedlings.

(*b*).—Bowman-Northway set of Pará rubber tapping tools, and Holloway's hook-pattern tapping knife.

quite clear from this what purpose the mere smoking is intended to serve, if the alcoholic solution has done its work by effecting a chemical union with the latex already.

Several rubber-washing machines, notably some small enough for experimental purposes or for demonstrations, were exhibited by Messrs. Walker Sons & Co., likewise sets of tapping knives, the simplest and best of which seemed to us (*vide* illustration) the Bowman Northway set for Pará and the Macadam for Castilloa.

8. We would close this chapter with a short notice of the very useful lectures delivered by Messrs. Green and Petch upon insect and Fungoid Pests, and upon the prevention of disease generally. The main idea of the latter lecture has already been outlined in our chapter on mixed plantations, so we shall only fill in from it the blanks in our sketch. We hope, among other things, that the lessons taught by these gentlemen may lead to a reconsideration of the Lower Burma Rubber Concession Rules referred to in Chapter VIII, or at least induce the other Local Governments to whom they have been circulated as models to refrain from adopting the provisions they contain fixing an arbitrary maximum interval between trees by prescribing an arbitrary minimum number of trees per acre. Mr. Green's remarks are so much to the point that we take the liberty of transcribing them as they stand (*Ceylon Observer*, 20th Sept., 1906:—)

"At present we have comparatively few insect pests of the Hevea plant in Ceylon. But it would be foolhardy to expect perpetual immunity. The history of every cultivation has shown that with increase of area and lapse of time new pests arise, attracted by the altered conditions and an abundant supply of food. Our system of exclusive cultivation of single products, though convenient for economic purposes, lends itself to the rapid spread of pests and calls for special measures to meet this liability. Plants —in their natural state, where numerous orders and species are intimately mingled together, are not nearly so subject to the ravages of disease. Apart from the physiological benefits of commensalism—now becoming more generally recognised—the more or less complete isolation of individual species that occurs

under natural conditions is itself a check to the extension of disease. These facts lead up to—what I consider the most important part of my subject—that of isolation. What were the conditions that prevailed during the reign of coffee, and are now equally or even more pronounced in the age of tea? We find vast continuous tracts of land planted with a single product, unbroken by either natural or artificial boundaries, and affording no hindrance to the free distribution of any infectious disease. Under such conditions how can we hope effectually to deal with our insect enemies? Vigorous measures may be employed and a pest may be temporarily exterminated on a limited area; but the disinfected parts are immediately liable to fresh invasion from all sides. Given an isolated field we can deal with a pest with some confidence that our labour will not be quietly nullified. I would most earnestly urge our rubber planters to take warning from the mistakes that have been made in the cultivation of the older staple products of Ceylon. The remedy lies in the formation of belts, boundaries, of either jungle or cultivated trees. Such belts should be at least 20 feet in depth and composed of good growing trees with a good cover of foliage. As in most trees the lower parts are bare of foliage a separate undergrowth will be necessary to ensure an effective screen. It is also important that the trees and shrubs composing the belts should be of kinds differing as widely as possible from the plants that are to be protected by their means. Insects, though seldom dependent upon a single species of plant for their nourishment, very generally confine themselves to distinct groups of nearly related species and genera."

In this connexion Mr. Kelway Bamber's remarks in the course of the discussion following Mr. H. Wright's paper of 17th September deserve equal prominence. Mr. Bamber said:—

"The Hevea being a surface feeder more or less, the exhaustion (of the soil) is rapid. I myself think that 15 by 20 feet should be the minimum distance at which rubber should be planted. The actual growth of the roots far exceeds what is calculated—a foot a year—and in three or four-year roots it may extend to 15 feet or 20 feet. The roots of many trees planted 15 by 20 have already crossed and passed each other, forming a lace-work. It remains to be seen how far you can cut these roots without interfering with the flow of latex in the trees. I think that for that reason alone the greatest care should be taken not to go in for too close planting. Coming here in the train yesterday I noticed rubber planted 8 feet by 8 feet. It seems to me that this is absolutely throwing money away."

PLATE XVI.—Pará rubber. Taproot and mode of extension of the lateral rootlets.

The Perak Government have issued a circular on this subject, quoted in the *Malay Mail* of 13th September, 1906, laying it down that in all future grants of rubber lands, protective belts of jungle not less than 10 chains in width should be reserved. This is as it should be, in principle at least, whatever incidental objection may be taken to it as a hard and fast rule.

We have already made reference to a very dangerous enemy of Hevea, the fungus known as Fomes semitostus, which breeds in decaying stumps and spreads underground to the roots of the living plant. Another very objectionable pest is the canker or nectria, for a description of which and the best means of curing it reference should be made to the Ceylon Agricultural Circular No. 29 of January 1905. Mr. Petch in his lecture draws attention to the general principle on which these pests should be dealt with, and closes with four pieces of advice which deserve literal quotation, and to which we would add a fifth, taken from Dr. Willis' summary of the lessons of the Rubber Exhibition :—

"(i) Pay more attention to nurseries; (ii) do not use immature seed; (iii) get rid of jungle stumps; (iv) do not be in too great a hurry to adopt schemes which involve extensive thinning-out; and (v) keep in hand a few sprayers and sufficient chemicals to deal with an ordinary outbreak of disease."

The list of this stock, according to Mr. Green, should at least extend to the following:—

Paris Green	...	...	...	2 cwt.
Sulphur	...	...	...	2 „
Whale Oil Soap	...	...	...	2 „
Lime	...	...	...	50 bushels.
Sulphate of Copper	...	...	...	1 cwt.

2 knapsack spraying machines for liquids.
2 „ „ „ „ powders.

ALPHABETICAL INDICES.

I.—SUBJECT MATTER.

A.

B.

C.

D.

E.

F.

G.

H.

II.—PERSONS, PLACES, PUBLICATIONS.

B—*contd.*

C.

D.

G.

H.

J.

K.

L.

M.

N.

O.

P.

R.

S.

T.

V.

W.

MISCELLANEOUS—*contd.*

Rs. A.

Beddome's Ferns of Southern India, being descriptions and plates of the Ferns of the Madras Presidency, by Major R. H. Beddome, Inspector of Forests, Madras. Second Edition, 1873. Published at £6 10*s.* for .. 13 0

*** *A fine large quarto (12 x 10) allowing the plates to have the detailed drawing so essential in botanical plates. It is this detail that has so raised the value of Wight's well-known botanical works, now so scarce.*

——— The Ferns of British India, being Descriptions and Plates of the Ferns. Roy. 4to, *with 345 plates; in two volumes, half morocco, extra scarce* .. .. 1870 .. 80 0

Tobacco Cultivation, by Clarence W. Dorsey, 1903 .. .. 0 8

Aloe, Sisal and Ramie Fibres; Dye and Tanning Stuffs; Drugs, etc., Notes on, by J. Ferguson 1 8

Pepper, All About. Giving practical instructions for Planting, Cultivation, and Preparation for Market 1 0

Cinnamon, All About. Giving practical instructions for Planting, Cultivation, and Preparation for Market, with information from a variety of sources 1 0

Grub. All About. Including a Paper on the Grub Pest in Ceylon, being the Result of Observations on the Cockchafers and their Larvæ in connection with Coffee and other Planting, by R. C. Haldane. .. 1 4

Areca Palm, All About the (Betel Nut), and specially its Cultivation in Ceylon to guide intending Planters, by J. Ferguson 1 0

Palmyra Palm, Borassus Flabelliformis: a Popular Description of the Palm and its Products, having Special Reference to Ceylon. With a valuable appendix embracing extracts from nearly every author that has noticed the Tree. Illustrated by wood Engravings. By the late William Ferguson, F.L.S. 2 0

Wynaad (The) and The Planting Industry of South India, by Francis Ford. Chapters on The Wynaad; The Planting Industry; The Planter's Life; The Rolling Year; Coffee and its Cultivation; Tea and its Cultivation; Labour and Land; Conclusion 1 0

All About the "Cocoanut Palm" (*Cocos Nucifera*) including practical instructions for planting and cultivation, with expenditure and receipts, and a special chapter on desiccating cocoanut, etc., by J. Ferguson, 1904 .. .. 4 0

Indian Amateur Dairy Farm.—Containing most useful information for the Dairy Farmer on Dairy Cattle Management, Milk, Cream, Butter, Cheese, the Production of Meat, Goats, Goat-milk, Pigs, Poultry, Rabbits, Pigeons, with a Chapter on Bees and their treatment in India, by "Landolicus." With 31 Woodcut Illustrations. Crown 8vo. Cloth .. 5 0

Our Mountain Ranges, how their resources may be turned to account and India converted into the garden and grain store of the world, by W. G. McIvor, illustrated by G. Balcock 1 8

Cardamon Cultivation, Notes on. With an Estimate of Expenditure and Return for 25 acres, and Notes on the Estimate, by T. C. Owen .. 1 0

Reports on the Agricultural Conditions, capabilities, and Prospects of the Neilgherry and Coimbatore Districts, by W. R. Robertson, M.R.A.C. .. 1 8

MISCELLANEOUS—*contd.* RS. A.

Forestry in Southern India, by Major-General H. R. Morgan, Edited by John Shortt 2 8

*** *A Manual for the Young Forest Officer, containing valuable information about teak forests, management of teak forests, sandalwood, dry forest, notes on "Acacia melanoxylon"—depôts—forest labour—health—treatment of seeds—list of trees—fuel plantations—Humus and the defertilisation of forest soils—forest products, etc.*

Agriculture in Madras. A lecture read before the Society of Arts, London, by W. R. Robertson, M.R.A.C., Superintendent of Government Farms in Madras Presidency 0 8

Modern Agriculture, and what modern agriculture can do for Indian Farmer; being two lectures delivered in the Government Central Mesuem, Madras, by W. R. Robertson 0 8

Indigo.—An essay on the Culture and Manufacture of Indigo, which was awarded the prize of Rs. 800 by the Madras Government, with a Tamil translation by John Shortt, M.D., F.L.S. 1 12

Directory of the Chief Industries of India.—Comprising the Tea and Indigo Concerns, Silk Filatures, Sugar Factories, Cinchona Concerns, Coffee Estates, Cotton, Jute, Rice and Flour Mills, Collieries, Mines, etc. With their Capital, Directors, Proprietors, Agents, Managers, Assistants, etc., and their Factory Marks, and a Directory of Estates in Ceylon. A Complete Index of names of Gardens and of Residents. With a map of the Tea Districts and 4 maps of the Products of India. *Annually in Feb.* 7 8

Cattle Diseases, Extracts from Manuals of the more deadly forms of Cattle Diseases in India, by Thacker and Hallen, with translations into Tamil opposite the English 1 0

The Mango, by G. Marshall Woodrow, with illustrations and coloured plate 1 0

Brandis' Indian Trees. 1906. .. .. 14 0

BOOKS NOT IN THIS CATALOGUE

can be procured from London in 7-8 weeks, or if customer sends value (and postage) in advance, we can instruct our London House to post *direct*, in which case the books are usually delivered in 5-6 weeks. *American books usually take longer.*

We are often able to procure books in India, from our agents in various parts, thus saving the usual 8 weeks' delay.

If you cannot find the book you are looking for in this list, please write. This is a list of books in stock in February, 1907, so that any books received since then do not appear.